

T H E S I S

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on

THE SUTLEJ DEODAR
ITS ECOLOGY and TIMBER PRODUCTION.

by

R. MACLAGAN GORRIE, B. Sc.,
Indian Forest Service.

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MAP

INTRODUCTION.

The object of this paper is to trace the relationship between the plant associates of the deodar and its value as a timber tree. The deodar (Cedrus Deodara, Loudon) is the most valuable tree in the North-West Himalaya, and the Suttlej Valley forests are one of the main sources of its supply for the markets of Northern India.

The deodar occurs in a belt of forest along both sides of the Suttlej Valley stretching from the outer hills of the Lesser Himalaya to the Tibetan border, and it grows under climatic conditions varying from the heavy monsoon of the outer hills to the arid country behind the main ranges of the Himalaya, whose precipitation consists almost entirely of winter snowfall. The plants associated with the deodar vary greatly between these two extremes, and the correlation of these plants with the varying capacity of the deodar as a timber producer should serve a useful purpose in clarifying our knowledge of Himalayan silviculture.



TYPICAL DRY-ZONE DEODAR COUNTRY.

- (1) Yeti forest in the Bhabba valley; deodar confined to rocky spurs on a south-east aspect.
- (2) Kilba forests; pure deodar belt merging into Quercus Ilex below and blue pine--silver fir above.



CHAPTER I.

SITUATION and TOPOGRAPHY.

The Sutlej River flows from Western Tibet to the Punjab Plains, and has carved for itself a stupendous gorge through the central granite core of the Himalayas. For a distance of eighty miles of its course this river is the main geographic feature of the Upper Bashahr Forest Division. Bashahr State is the largest of the Simla Hill States and comprises over 3,000 square miles of territory, the major and more mountainous part of which is included in this forest division.

The area to be dealt with is commonly known as "Kanawar", and extends between longitude $77^{\circ} 40'$ and $78^{\circ} 50'$ East and latitude $31^{\circ} 20'$ and $31^{\circ} 50'$ North. The boundaries indicated in FIG. I are as follows:-

NORTH: Spiti, which is an isolated portion of British India behind the Himalayas.

EAST: The Nari Khorsum Province of Chinese Western Tibet.

SOUTH: Tehri Garhwal State (Sutlej-Ganges and Sutlej-Jumna watershed).

WEST: Lower Bashahr Forest Division (the Sutlej-Jumna watershed to Rampur on the Sutlej) and Kulu in British India (civil boundary line and Sutlej-Beas watershed).

The general structure of the Himalaya in this/

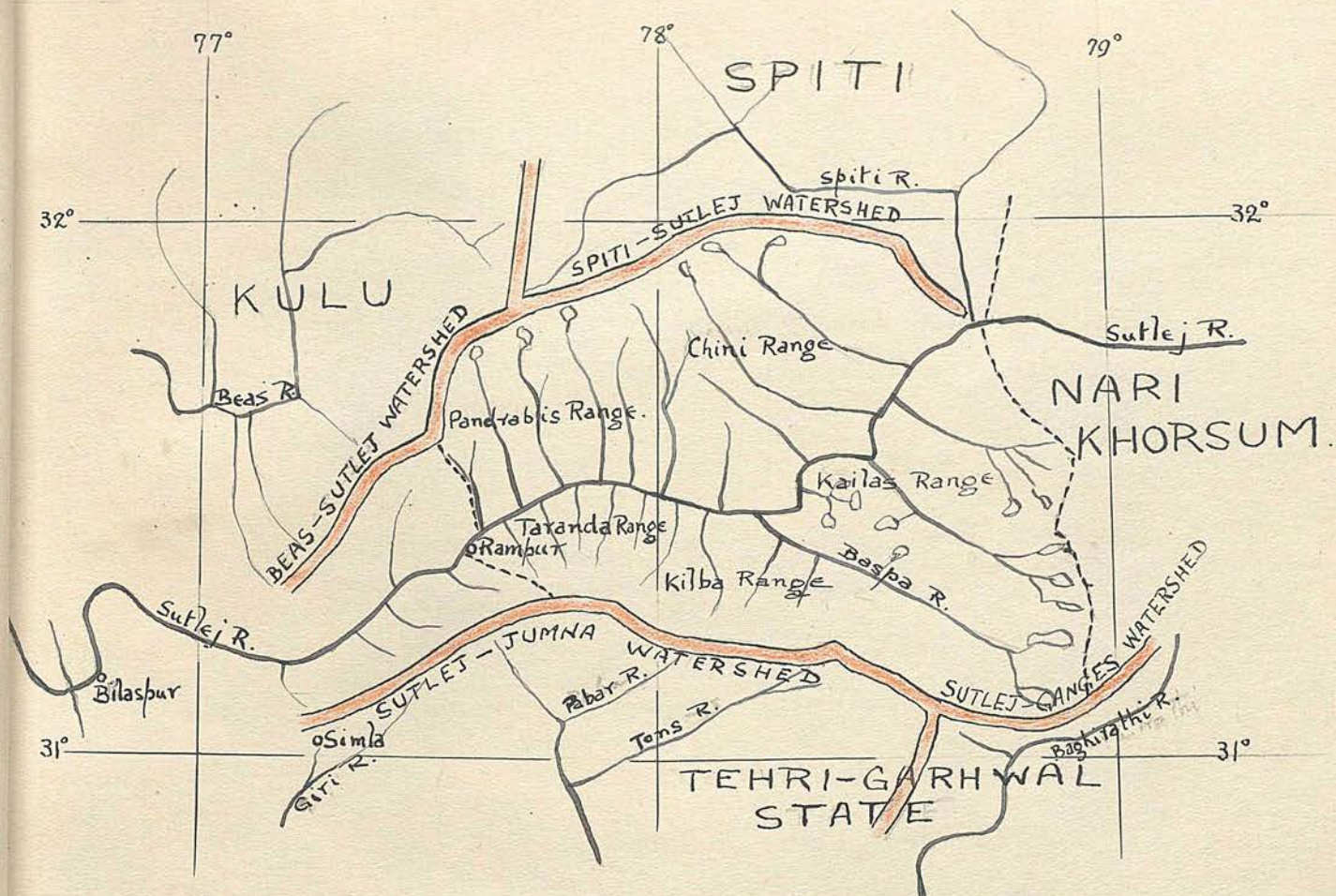


Fig.1.- Upper Bashahr Boundaries.

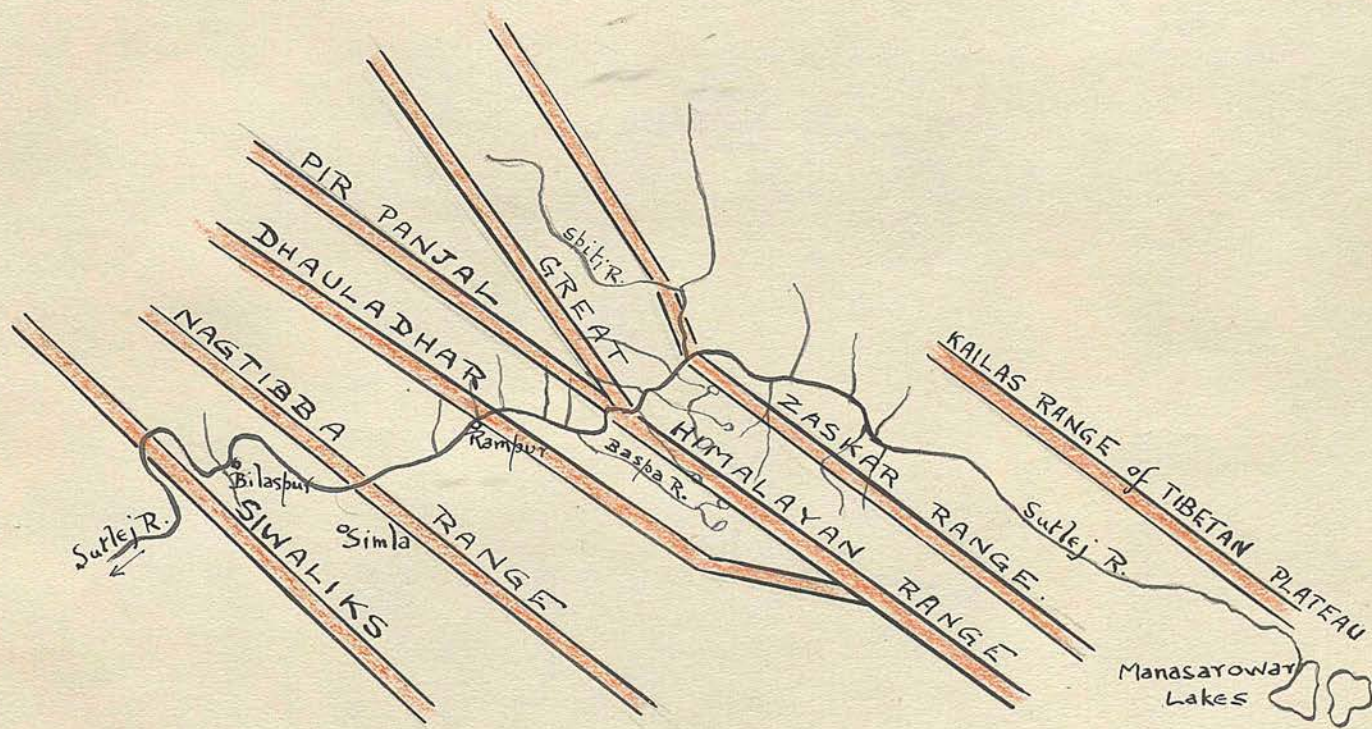


Fig.2.- Himalayan Ranges.

Scale: $\frac{1}{2}$ of Fig.1 above.

this area shows a series of 5 roughly parallel ranges running from east to west, the foothills of the Siwaliks making a sixth (FIG. 2). These ranges taken from north to south are as follows:-

1. The Zaskar Range, lying mostly in Western Tibet and Lahaul.
2. The Great Himalayan Range, forming the main axis of the chain.
3. The Pir Panjal, which branches off from the main axis in Bashahr and runs west towards Kashmir.
4. The Dhauladhar, which branches off from the main axis further east in Garhwal and runs west into Kulu and Chamba.
5. The Nagtibba Range, which is the line of the outer hills of the Lesser Himalaya.

The parallelism of these main ranges is clear on the map, but is anything but clear on the ground, for the Sutlej Valley in Kanawar is so completely hemmed in by mountains of from 17,000 to 21,000 feet that one has the impression that the main ranges must be parallel to, and not at right angles to, the Valley.

The Sutlej is the only one of the Western Himalayan Rivers to cut its way through both the Zaskar and Great Himalayan Ranges. The level of the river bed drops from 10,000 feet to 3,000 feet in the eighty miles of its length in Kanawar, giving an average gradient of 88 feet per mile, - a very high/

high rate of fall for such a large river. Its bed is 600 to 700 feet lower than the corresponding levels of its neighbours, the Beas and the Giri (Jumna). These points all indicate the enormous erosive power of this river.

The main catchment area of the Sutlej lies in Tibet, and the stream has a course of roughly 200 miles before entering Bashahr, by which time it is a large river carrying the drainage of many glaciers lying on the northern slopes of the Nepal and United Provinces Himalaya. Its catchment area in the outer Himalaya is relatively insignificant for a river of its size, for below Rampur it is confined to a basin only 20 miles wide by its two smaller neighbours, the Beas and the Giri. Between the Tibetan border and this bottle neck of the outer hills, the main tributaries are the Spiti River, draining both flanks of the Zaskar Range, the Baspa draining the Nela and the Nithal Glaciers, and some two dozen minor side-streams of appreciable size, varying from 10 to 30 miles in length and fed from the snowbeds and smaller glaciers of the surrounding mountains.

The river cuts through the Zaskar Range just where it enters Bashahr and close to the highest point in the range; Lio Porguil, 22,210 feet high, has/

has its summit only three miles map distance from the bottom of the Suttlej Gorge at 10,000 feet, and for several miles downstream from this point the right bank is an almost perpendicular cliff towering more than 6,000 feet above the river. The actual point of junction of the Spiti and Suttlej rivers is hidden from all sides by these colossal cliff walls.

Thirty miles below the Spiti junction the Suttlej cuts through the axis of the Great Himalayan Range, giving rise to another stretch of magnificent cliffs between Shongtong and the junction of the Baspa and the Suttlej. This gorge makes a break in the geological unity of the range, which west of the Suttlej, splits into two, the Pir Panjal running west and the Great Himalaya Range turning north-west.

The Baspa marks another bifurcation of the main range for it runs between the Great Himalayan and the Dhauladhar Ranges, which split some distance to the east in Garhwal. The Suttlej cuts through the Dhauladhar at a point about twenty miles below the Baspa junction, thus forming a third great series of cliff gorges below Taranda and Chaura.



The GORGES of the SUTLEJ.

- (3) The Sutlej face of the Kanawar Kailas group of
21,000 foot peaks.
- (4) The Chini cliffs, where the Sutlej has cut through the
granite core of the Great Himalayan Range.



CHAPTER II.

GEOLOGY.

The rocks of the Sutlej Valley in Bashahr are grouped in three great bands running roughly east and west, the granite core of the Himalaya forming a central belt which separates two sedimentary zones, the Tibetan to the north and the Himalayan Purana Group to the south. The Tibetan group is equivalent to the European Silurian and Devonian eras, while the Purana group is very much older and is related to the pre-Cambrian deposits of the Indian peninsula.

The main axis of the Great Himalayan Range, including the line of most of the great peaks, lies in a continuous belt of granite and associated crystalline rocks. This central core is exposed to a greater depth in the Sutlej gorge than in any other part of the Himalayas, and Wangtu Bridge, 120 miles from Simla along the Hindustan-Tibet Road, is recognised as the best place for this to be studied. The granite shows a wide range in crystallisation, but is commonly very coarse with much biotite (black mica), large pieces of felspar, and a marked absence of/

of hornblende. A very common feature is a conspicuous banding of the granite into a laminated gneissose type of rock, which, when weathered, can easily be mistaken for a metamorphosed sedimentary deposit. Another and extreme type of weathering is where the granite mass is reduced to pure white sand, well seen in the soft sand cliffs of Poari in Kailas Range.

Overlying the granite and covering large stretches of the valley slopes from Rampur up to the Tidong River junction, there is a strange medley of crystalline schists and quartzites, passing in a few places into garnetiferous slate sufficiently good to use for rough roofing slabs. The amount of highly metamorphosed material is so vast and so incoherent that it is exceedingly difficult to give any exact line for the beginning of the sedimentary zones to north and south of the granite, but the sketch map shows their approximate position (FIG. 3).

The sedimentary deposits of the Himalayan Purana group, which have been studied in such detail in the neighbourhood of Simla, and which form the main bulk of the outer ranges, fall just outside the area now dealt with. In the Sutlej Gorge just below Rampur the lowest and oldest of the "Simla Series"/

Fig. 3.

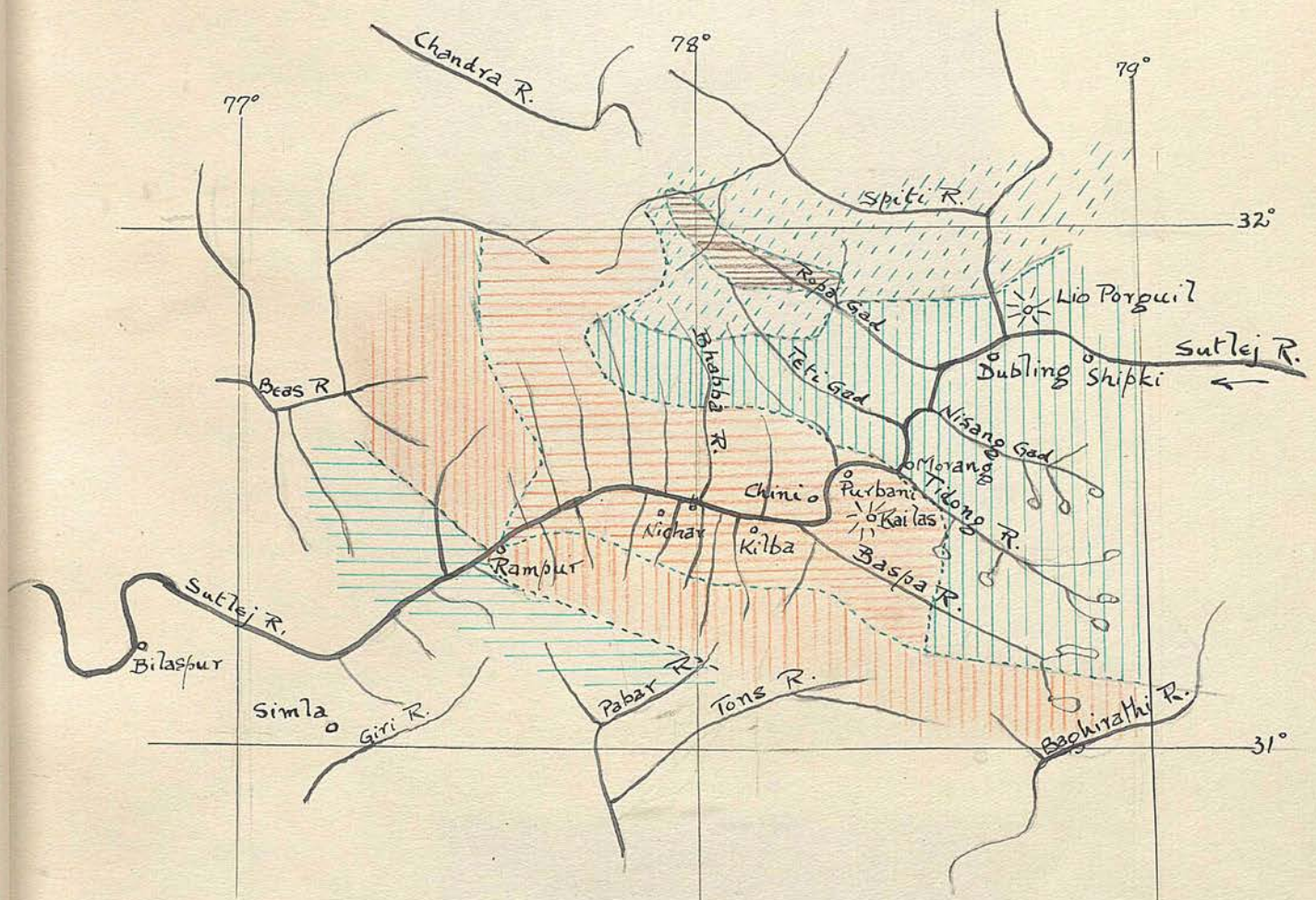






Fig. 3. Geological Sketch of Sutlej Valley.

Tibetan Zone	{	Lilang and Kanawar Shales		
		Haimantha and Muth slates and quartzites		
		Limestone		
Himalayan Zone	{	Purana Group slates and quartzites		
		ditto, much metamorphosed		
		Granite and crystalline schists		

Series" appear as steeply tilted beds of slates and quartzites lying across the river bed and unconformable to the mica schists adjoining them. These slates are also traceable at a higher level in the Nogli valley, but are nowhere of much consequence as agents in soil formation, the overlying mica schists being so much more in evidence.

To the north of the granite belt the great mass of the Tibetan sedimentary rocks has been studied along ^{the} Spiti-Sutlej water-shed, and much has been written by various members of the Geological Survey of India about this area. The enormous thickness of the Tibetan plateau has been built up from a series of deposits laid down by the ancient Tethys Sea, and since upheaved by the emergence of the Himalayan chain. The rocks most in evidence in Bashahr are amongst the oldest of this vast accumulation, and consist mostly of red quartzites and highly coloured friable slates and shales, with an occasional outcrop of limestone, and of black "Productus" shale. These all belong to the older Tibetan rocks of the Haimanta and Muth systems, while the younger rocks of the Kanawar and Lilang systems are found only in the further reaches of the Spiti valley and the heads of the Ropa and Teti valleys/



GEOLOGICAL STUDIES.

- (5) Banded quartzite cliffs in Shorang Gad, one of the Pandrabis valleys rising on the Spiti border.
- (6) Cliffs cut through the Haimanta shales at the junction of the Sutlej and Spiti rivers.



valleys. The general result of all these is the formation of a dry shaly and very porous soil, somewhat less fertile than the more easily weathered granite soils. The alteration from granite to shale is more easily marked on the sky-lines of ridges than in the composition of the soil, because the sharp and jagged outlines of the granite alter to softer and more uniform curves in the shale. This demarcation is best seen where the Tidong joins the main river, the hills to the south being the jagged granite aiguilles of the Kanawar Kailas group, while to the north and east the crests are much softer and more gently rounded.

The geological composition of the soil, however, is not an important factor in the plant ecology of the Sutlej compared with the physical condition. Given equal moisture conditions, deodar will grow almost equally well on any one of the gradations from the mica sand of the true granite to the friable clay-loam of the shale formations. The sudden differences in growth so noticeable in dry zone deodar are due, not to any alteration in the underlying rock, but to the influences of aspect and insolation, while the gradual diminution in tree growth towards the Tibetan border is primarily a question of moisture distribution.

CHAPTER III.

CLIMATE.

The climate of the Sutlej valley shows a gradual alteration from the heavy monsoon of the outer Himalaya to the arid Tibetan type with a winter snowfall and practically no summer rain. The monsoon clouds advancing from the plains of India are combed out by the outer ranges of the hills, where most of the monsoon rain falls, so that the inner valleys get a good deal of cloud but no steady precipitation during the monsoon months. The snowfall is also heavier in the Himalayas than it is on the Tibetan plateau, but the zone of heavy snowfall includes the whole of the Bashahr Sutlej, and it is only beyond the Tibetan border and in further Spiti that the snowfall shows any marked decrease.

(a) RAINFALL.

The Himalayan valleys which open due south towards the plains form pathways up which the monsoon clouds are swept, but the Sutlej valley lying east and west is badly placed for rainfall, and a further local aridity is caused by storm clouds being/

being checked in their progress up the valley by one or other of the many steep spurs which shut it in. This local aridity is increased by the heating up of the enormous stretches of bare cliff, making the deep narrow gorge absolutely stifling under the summer sun. This in turn gives rise to a hot drying local wind, which beats down the gorge every afternoon with great regularity. Thus Rampur at 3,000 feet in the bottom of the gorge has a rainfall of 35", while Kotgarh at 8,000 feet but in the same sector of the valley has 45".

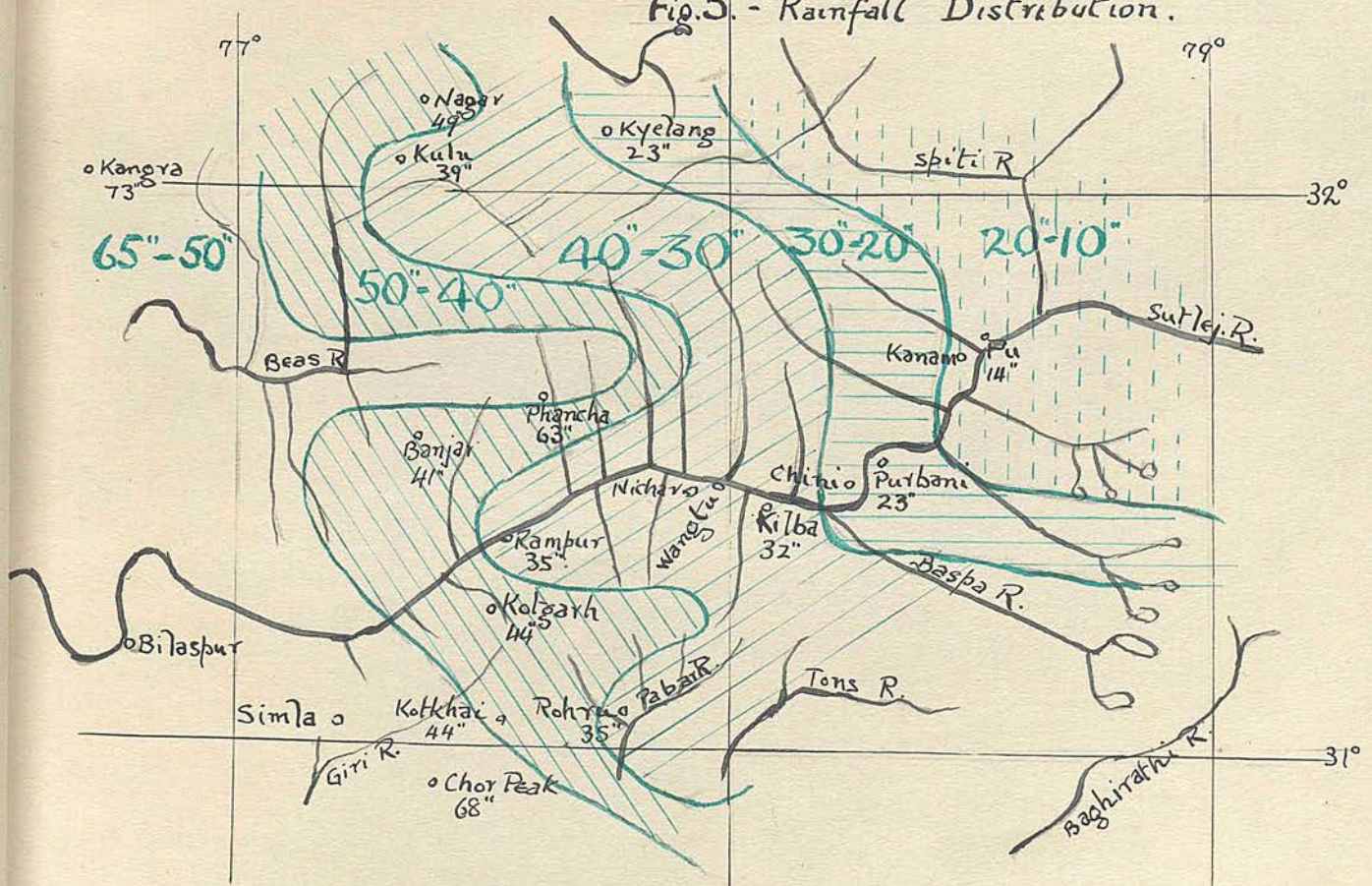
The Pandrabis Forest Range on the right bank adjoining the Kulu border, has a rainfall of approximately 65" compared with only 40" for the opposite left bank. This is doubtless due to the southern aspect of the high Spiti range receiving a heavier share of precipitation from the moisture-laden south-west winds.

Further up the valley the monsoon effect weakens appreciably beyond Wangtu Bridge and at Kilba the annual total of 34" shows a slight monsoon rainfall and a much enhanced snowfall, while at Pu near the Tibetan border there is a lighter snowfall and absolutely no summer rain. The following schedule (FIG. 4) shows a detailed comparison of the different/

Fig. 4. - Comparison of Rainfall.

Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total Annual.
4.73"	4.43"	3.81"	2.05"	2.30"	9.92"	36.37"	37.12"	11.77"	1.06"	0.46"	1.73"	115.75"
Dharmasala:- heavy monsoon of Kangra Foothills.												
2.47	2.69	2.74	2.28	2.80	7.25	16.97	17.43	5.94	1.00	0.50	1.00	63.07
Simla:- medium monsoon of outer hills.												
2.19	2.67	3.55	2.77	3.06	4.34	9.80	9.57	4.33	0.86	0.48	0.94	44.56
Kotgarh:- light monsoon of middle hills.												
3.65	3.64	5.24	3.48	2.46	1.52	3.55	2.92	2.69	0.84	1.08	1.34	32.41
Kilba:- dry zone of middle Kanawar.												
2.06	2.14	3.24	2.24	0.90	0.25	0.59	0.56	0.53	0.50	0.30	0.73	14.04
Pu:- arid zone of upper Kanawar.												
0.36	0.30	0.28	0.23	0.21	0.18	0.46	0.54	0.26	0.17	0.03	0.16	3.18.
Leh:- True Tibetan type.												

Fig. 5. - Rainfall Distribution.



different types. Snowfall is included at the ratio of 10 inches of snow to 1 inch of rain.

The Chart of Average Annual Rainfall of India published by the Surveyor General is not by any means accurate for the Sutlej valley area as it shows a rainfall of 40" - 50" for the entire area from Simla to beyond the Tibetan border. I have, therefore, tried to indicate the true position in the following sketch (FIG. 5).

Taking the Kilba figures as typical of the middle dry zone of the Sutlej, we find that since rainfall figures were first collected in 1882, wet years and dry years have fallen in cycles. The average for the 39 years up to 1920 was 32.41", but during the last five years of this period, namely 1916-20, the average was only 23.71". Since 1921, however, there has been a very definite wet cycle, the average for the five years 1922-26 being 47.66" with individual annuals of over 60" in 1924 and 1926. This marked wet cycle has increased the average over the 46 years 1882-1927 to 34.11".

These wet cycles do not necessarily take the form of a heavy monsoon, though on the whole they fall parallel with heavy monsoon years in the outer hills. The heaviest monthly totals for Kilba generally/

generally fall in March-April and again in September, and the heaviest individual storms are recorded in these months. The following figures of phenomenal rainstorms are interesting in enabling one to visualise the colossal destruction which such sudden storms must cause in a steep country with a dry open vegetation incapable of protecting the soil from erosion.

<u>March.</u>	<u>April.</u>	<u>September.</u>
19.3.22 : 5.05"	7.4.22 : 4.02"	26.9.24 to
31.3.22 : 3.01"	18.4.26 to	30.9.24 : 27.80"
29.3.26 : 3.00"	21.4.26 : 13.16"	in five days
	in 4 days	

The only regular dry period in these hills falls in October-November and occasionally up to the middle of December, depending on when the first heavy snowfall breaks this autumn drought. There is a less regular but none the less dangerous dry period in May - June, which often causes serious loss in forest regeneration areas, but which is not apparent from the average monthly rainfall figures taken over a period of several years, as this early summer drought is an intermittent one.

(b) /

(b) SNOWFALL.

Rough measurements of the seasonal fall at different points throughout the deodar belt were made during the two winters 1927 to 1929, and it was found that the fall was fairly uniform throughout the valley for any given altitude above 9,000 feet, but that below this point the fall was much heavier in the dry Chini-Kailas sector than in the nearer sectors of Taranda and Pandrabis. This agrees with the local belief that the winter climate for the valley beyond Kilba is much more severe than in the outer ranges. Approximate averages of the cumulative depth of snowfall are as follows :-

Feet above sea-level	6000	7000	8000	9000	10,000
Chini-Kailas	7 ft.	10 ft.	14 ft.)		
) 14ft.	18 ft.
Taranda-Pandrabis	4½ ft.	8 ft.	10 ft.)		

Falls at 5,000 ft. occur fairly frequently in January and February, but seldom lie for more than a few hours. The lowest fall recently recorded was $\frac{3}{4}$ " of snow at Rampur at 3,000 ft. in February 1929.

At 6,000 ft. the rate of melting is fairly uniform for all aspects, but it seldom lies for more than 3 - 4 days even in the most sheltered places. From 7,000 to 10,000 feet, however, the depth of snow/



EARLY SUMMER SNOW LEVELS.

- (7) Deep snow lying in spruce belt in end of April;
Manglad Gad forests.
- (8) Snow still lying in high-level silver fir belt and alpine
pastures in end of May; Panwi Gad forests.



snow accumulations varies enormously with the aspect, sunny slopes being cleared quickly, while ravines and sheltered sunless slopes retain unmelted snow for long periods. The spring weather subsequent to heavy falls also affects the melting period, for continued "muggy" weather and mild rain melts the snow much quicker than clear dry sunshine. On northern aspects snow generally remains on moderate slopes at 7,500 feet until towards the middle of April, while southern slopes are clear up to over 9,000 feet by then. At the base of huge cliffs and in the lee of the great snow peaks the spring sun may only shine for 1 to $1\frac{1}{2}$ hours per day, hence such places retain their snow for much longer. Accumulations in ravines are increased by snow sliding down from above and packing itself hard, hence snow bridges are commonly in use at 9,000 - 10,000 feet until August or even September. The level of eternal snow in Bashahr can be taken as 18,000 feet for open hillsides. Above this only sheer cliffs can be free of snow, and below this even the warmest aspects are free of snow for about two months, namely July and August. For the upper forest belt at 10,000 to 12,000 feet it can be taken that warm aspects are sure to be clear of snow by the beginning of May, while cold aspects, particularly those with gentle/



PERMANENT SNOW LINE at MIDSUMMER.

- (9) Northern exposure of the Kailas group of 21,000 foot peaks with deep snow above 18,000 feet and many small glaciers.
- (10) Southern exposure of the same group with snow lying only on rock shelves above 19,000 feet.



gentle north and north-west slopes, may hold snow-beds until the beginning of June. Data of snow accumulations at various heights have been collected by the Bashahr forest staff for a period of 23 years and a graph of these figures is given in FIG. 6.

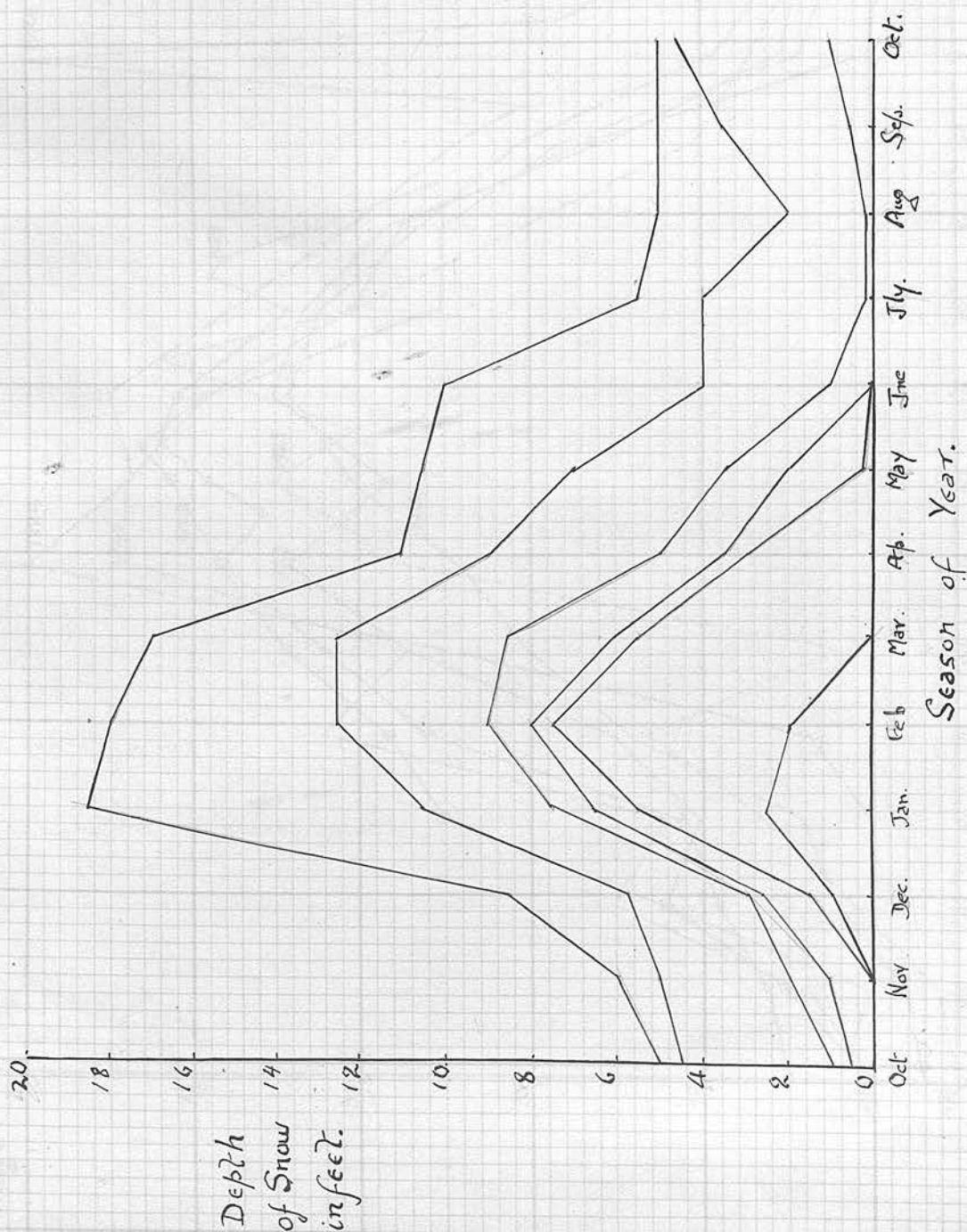
(c) FLOODS.

The combined effect of rainfall and of the melting of the snow is reflected in the behaviour of the Sutlej river, and figures showing the seasonal rise and fall have been collected over a period of the last seven years for the purpose of regulating the launching of timber during the fall of the summer floods (FIG. 7). It will be seen that the main summer rise is due to the melting of snow both in the upper catchment area in Tibet and in the nearer areas of Spiti and Bashahr, while phenomenal rainstorms, such as the great storm of September 1924, also make themselves felt.

The valleys in Bashahr are so deep and narrow that there is no possibility of serious flooding of the countryside, even were the gorge to be dammed up by a landslip, as has been known to happen. Floods are directly responsible, however, for the loss of enormous quantities of fertile soil, for in the/

FIG. 6. DEPTH OF SNOW ACCUMULATIONS AT VARIOUS HEIGHTS
ABOVE SEA-LEVEL THROUGHOUT THE YEAR.

Figures submitted by Divisional Forest Officer, Upper Bashahr,
to Meteorological Dept. of India over a period of 23 years.





DAMAGE by AVALANCHE WINDS.

(11) and (12) Fierce wind storms follow the descent of snow avalanches in the spring; 10 acres of fine deodar and blue pine pole forest practically clear-felled by wind in Kilba forests.



the dry zone the vegetation is so sparse and open that it does not provide an adequate soil cover against such contingencies, and even a relatively light rain-storm adds its quota to the very serious loss caused by erosion.

The rapid melting of snow also causes frequent avalanches, and they in their turn cause fierce and severe wind-storms, which do considerable damage. One case in point occurred in Sdilling, Compartment 14b, in Kilba, where an avalanche wind completely clear felled about 10 acres of fine deodar and blue pine pole forest.

(a) SOIL TEMPERATE^{ur} AND RELATIVE HUMIDITY OF AIR.

During the three years spent in Upper Bashahr I collected a considerable amount of data of soil and air temperatures by taking thermometer readings several times a day while in camp, thus getting readings for a great variety of sites and altitudes. Unfortunately I was unable to secure a really suitable form of soil thermometer until shortly before leaving for home, and most of the soil readings were taken with small bath thermometers, which gave readings at depths of 2" to 6". These/

These are hardly comparable with standardised readings made in test stations. The soil surface temperatures are also difficult to compare with readings taken under standard conditions, for these were collected with a maximum and minimum thermometer set up at ground level in any condition of shelter or exposure which offered itself near my tent. They do, however, give a clear indication of the immense drops between day and night temperatures in the dry zone forest belt of Bashahr.

The relative humidity readings are more strictly parallel with standard conditions, as they were always taken with a wet and dry bulb thermometer set up near ground level under average conditions of shelter and protected from any unusual draughts.

The main object of these readings has been to construct:-

- (a) a composite schedule of averages to show seasonal changes (FIG. 8), and
- (b) a comparison of figures collected for open ground as against canopied forest under parallel conditions (FIG. 9).

The seasonal scales compounded for average open conditions at 7,000 and 9,000 feet show that May and October are quite as hot as the midsummer months, but have a much lower relative humidity for midday, hence causing arid and difficult conditions for/

FIG. 8.

CONDITIONS of TEMPERATURE & HUMIDITY
THROUGHOUT the YEAR at approximately SIMILAR
STATIONS for 7,000 feet in open - UPPER BASHAHR.

MONTH	RELATIVE HUMIDITY %			SOIL TEMPERATURES		DEGS. FAHR.	
	Morning	Noon	Night	Surface	Max. Min.	At 2" depth	Max. Min.
Aprl.	80	67	72	120	40	82	49
May	72	37	69	128	45	86	51
June	68	46	66	129	45	90	60
July	98	66	99	139	54	93	62
Aug.	95	71	94	125	56	75	66
Sept.	86	52	86	129	55	88	64
Octr.	97	36	84	128	41	92	48
Novr.	73	40	75	116	32	82	50
Decr.	74	58	72	86	29	51	34
* { Jany.	77	61	80	85	21	53	30
* { Feby.	93	74	89	86	16	50	30
* { Mch.	69.	40	69	112	30	78	37

DITTO AT 9,000 FEET IN OPEN.

May	50	31	45	135	41	84	54
June	76	40	70	129	43	89	60
July	88	71	92	123	54	93	62
Aug.	97	50	97	128	50	88	64
Sept.	84	42	84	122	32	80	48
Octr.	76	38	68	104	31	64	47

*

Taken at Simla so probably temperatures should be lower for Bashahr winter.

FIG. 9.

COMPARISON of TEMPERATURE & HUMIDITY
In OPEN and Under FOREST CANOPY under similar
conditions - UPPER BASHAHR.

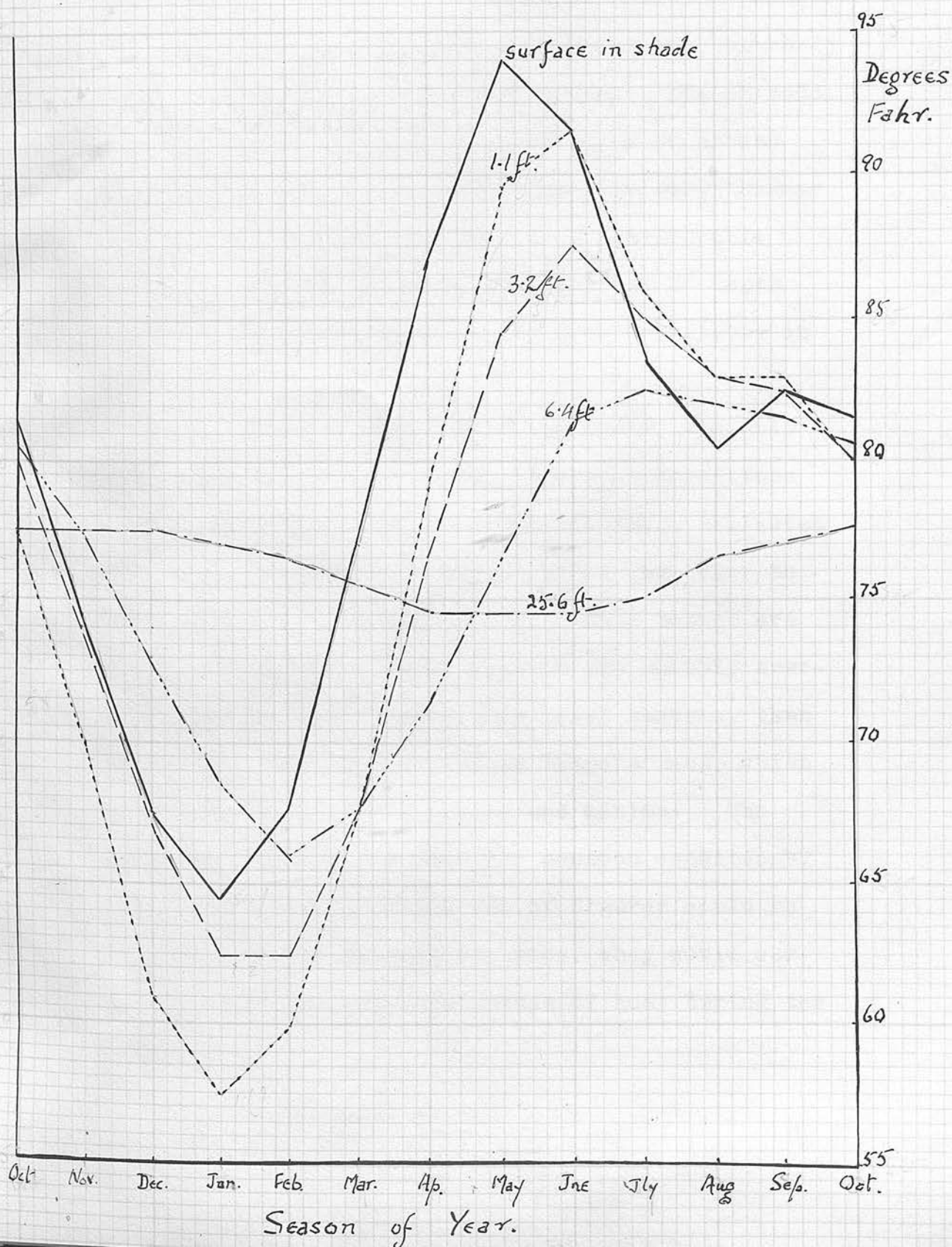
MONTH and SITUATION.	RELATIVE HUMIDITY %			SOIL TEMPS. DEGS.F.			
	Morning	Noon	Night	Surface Max.Min		At 2"depth Max.Min.	
<u>May</u>							
7000 ft.Open	72	37	69	128	45	86	51
Forest.	77	44	77	111	43	70	51
<u>June</u>							
7000 ft.Open	68	46	66	104	57	87	61
Forest	69	53	77	102	56	71	56
<u>June</u>							
8500 ft.Open	76	40	70	129	43	89	60
Forest	88	44	84	85	46	64	54
<u>Aug.</u>							
7000 ft.Open	95	71	94	125	56	-	-
Forest	93	71	88	104	57	-	-
<u>Octr.</u>							
7000 ft.Open	79	22	79	115	31	93	50
Forest	69	40	70	90	44	68	51
<u>Novr.</u>							
7000 ft.Open	73	40	75	116	32	82	50
Forest.	57	38	60	87	40	62	50

for plant life. The midday drop in humidity throughout the summer months is a characteristic feature of the drier Himalaya where the monsoon is ineffective.

The comparison of forest and open figures shows that the midday drop in humidity is less extreme under forest than in the open, although morning and night humidities are frequently lower in forest than in the open. This indicates the leveling effect which a forest canopy has in preventing extremes of aridity and excessive humidity. The temperature readings for soil surface and soil at 2" depth also show that a forest canopy prevents extreme fluctuations, the forest maximum being always lower than in the open, and the forest minimum being frequently higher.

The soil surface maximum of 140° Fahr. is registered frequently in May and June, but the surface temperature remains uniformly high from May to November, dropping to 80° for the winter months. The soil surface minimum is regularly about 50° from April to September and drops to 30° during November to March. The widest range between day and night temperatures is invariably in October-November, and drops/

Fig.10, Comparative Temperatures of Soil at Various Depths throughout the Year for Monsoon Conditions. Curves constructed from Trigonometrical Survey figures for Dehra Dun, 1900 to 1912.



drops from over 130° in the sun to below freezing point at night are a common experience in autumn camps.

Soil readings at 2" depth show big daily divergences between maximum and minimum in the early summer and again in October-November. The 6" soil readings which have not been quoted, also showed these divergences, and showed that the early summer heat particularly, is absorbed to a considerable depth of soil, readings of over 100° at 6" depth being fairly common in open dry zone conditions in May - June - July.

For comparison with the above, the only soil temperature figures for Himalayan conditions which I have been able to trace, are those collected by the Trigonometric Survey at Dehra Dun prior to 1912, and curves constructed from this source are shown in FIG. 10. These figures are monthly averages and thus show a much more level tendency than my Bashahr figures for surface temperatures, which are booked under daily maxima and minima. The Dehra Dun figures are also for monsoon conditions, and if an exactly similar set of figures could be produced for the Bashahr dry zone, they would certainly show a steady maintenance of heat during the summer/

summer months instead of the sudden drop caused by the heavy monsoon which cools the outer hills.

(e) INSOLATION OF SOUTH-FACING SLOPES.

The direction of slope is the decisive factor in determining local changes in the forest flora, and this is due chiefly to the insolation which south-facing slopes have to endure from prolonged exposure to intense sunlight falling at approximately right angles, compared with the north-facing slopes, which only bear an oblique sunlight for a much shorter period each day. In the Sutlej Gorge and on the slopes above it the sun beats mercilessly down on great expanses of rock and unprotected soil, and the aridity of the southern aspects is emphasised by the uniformly steep angle of slope, from which rain and snow water drain off at once. The average relative humidity is also very much lower than on cooler aspects. Although the southern face of high ranges such as the Pandrabis hills of the Beas-Sutlej watershed collect a heavy rainfall, the effect is only noticeable at the higher elevations and within the deep enclosed glens which drain this area.

The ecological development of the south-facing slopes in such an arid valley as the Sutlej appears to be a retrograde one, because a vicious circle/



INSOLATION of SOUTHERN EXPOSURES in Moist Zone.

- (13) Mouth of Ganwi Gad, showing bare cliffs above Sutlaj and forest belt behind in shelter of the side-valley.
- (14) Hot grass-lands of Pandrabis with scattered deodar on spurs above 8000 feet and Quercus semecarpifolia belt at 10,000 to 11,000 feet.



circle has been formed:- aridity, insolation, and steep slope failing to conserve moisture, lead to a poor type of soil cover; rapid insolation under the morning sun causes sudden changes from night frosts to day temperature which weaken the existing vegetation; plant life is gradually driven out, and with the removal of the soil cover which has retained and protected the soil, the conditions become more arid and the soil is washed down the water-courses, or buried under rock screes.



INSOLATION of SOUTHERN EXPOSURES in ARID ZONE.

- (15) Northern exposure of Nisang Gad with a scattered growth of deodar and juniper cushion-scrub.
- (16) Southern exposure immediately opposite; 4000 feet of bare shale screes.



CHAPTER IV.

OTHER ECOLOGICAL FACTORS.

(a) POPULATION AND EMPLOYMENTS OF PEOPLE.

The villages in Kanawar are mostly situated in a belt of cultivation which runs along the slopes of the left bank at about 6,000 - 7,000 feet, in the fringes of the deodar forest. On the more arid southern exposures of the right bank the cultivation is less regular and generally lies at about 8,000 - 9,000 feet. A recent development is the extension of high level cultivation for summer catch-crops, and since 1916 large areas of spruce and silver fir forest at about 9,500 - 11,000 feet have been disforested for this purpose. The principal food crops are barley and wheat in the early summer, and buckwheat, amaranth, pulse and millet in the autumn. The people also depend largely on the dried fruits of the cultivated apricot, peach and apple, and on the edible nut of Pinus Gerardiana, while the poorer castes also use flour from ground horse-chestnuts. The cultivated area is not large enough for the needs of the people, and large quantities of grain are/

are imported by the trading clans of Kanawar, who carry on a seasonal carrying trade between Tibet and the lower hills with their enormous herds of pack goats and sheep.

The incidence of population and domestic animals is approximately as follows for the Kanawar portion of Bashahr State:-

Population :	25	per	square	mile.
Sheep and goats :	60	"	"	"
Cattle, yaks, ponies	7	"	"	"
etc.				

The incidence of population is thus small, but it must be remembered that it is crowded into a relatively narrow area between the arid gorge below and the wide stretches of eternal snow above, and that its maximum activity is at the level of the most valuable forests. The needs of the people in forest produce are : land for cultivation, coniferous timber for house building and repair, hardwoods for ploughs and implements, pine needles for litter, and broad-leaved loppings for fodder, all of which are acknowledged rights under the Forest Settlement. The grazing and browsing incidence, however, is not a very serious forest problem, as the arid scrub of the lower gorge and the immense stretches of alpine grass-lands meet most of their needs.

The religion of the middle hills is a Hindu animism in which each village has its own god made /



VILLAGE CULTIVATION.

- (17) Belt of villages and terraced cultivation between forest and river gorge in Taranda Range.
- (18) Blue pine pole forest destroyed by fire to clear ground for a crop of buckwheat.



made of embossed silver and yak's hair, while in the upper parts of Kanawar the people are almost entirely Buddhists. Both classes make a big demand upon the forest for timber for temple building, and in fact devote more time to this than they do to the proper upkeep of their own homes.

From the scanty historical records and from the evidence of old cultivation terraces over much of the ground which is now under deodar and blue pine (Pinus excelsa), it is obvious that the population at some fairly remote period was much larger than it is now. It was probably reduced by some great epidemic, and it is even now subject to great variations depending upon epidemic diseases amongst men and plough oxen.

(b) HISTORY OF FOREST DEVELOPMENT.

The Suttlej deodar forests were first worked by traders about 1850, and during the next few years the more accessible forests were very heavily felled. In 1864 the Raja of Bashahr, realising that he had lost all control over the timber traders to whom he had given concessions, asked the British Government to take over the forest management. Since that date the forests have been leased/

leased by the Punjab Forest Department, the raja receiving an annual rental, which has been gradually increased and is now worth about R75,000 per annum (approximately £5,600).

The more valuable forests, including most of the deodar-bearing areas, have been demarcated, and have been under some form of Working Plan since Messrs Brandis and Stewart wrote their first report in 1864. The Plan has been revised periodically (in 1875 by Brandis and Ribbentrop; in 1893 by J.H. Lace; and by G.S. Hart and A.J. Gibson in 1904) to provide for a conservative yield under a Selection System, under which the less accessible forests have been opened up. A yield averaging about 3,500 large deodar trees per annum has been obtained, mostly by departmental working, but with a period of exploitation by a commercial company during 1908-18.

Early work on deodar was restricted to the removal of individual mature and over-mature trees, but it was found that in the better parts of the deodar belt, profuse deodar regeneration often followed fairly heavy fellings. This was followed to its logical conclusion by making regular "seeding fellings", which in many forests have met with considerable success. In 1917 Sir George Hart, when/

when Inspector General of Forests, arranged for the immediate revision of the 1904 Plan in order to meet this development and regulate it. Unfortunately the revision of the Plan has been greatly delayed and even now it has not been carried through, although in the interval the fashion for making heavy regeneration fellings has been carried to an illogical extreme in the dry zone deodar belt where very few of the forest areas are fit for such treatment, and where a closer study of the ecological conditions would have prevented mistakes.

During the last two decades also the exploitation of the inferior conifer species, namely the blue and chil pines, and the spruce and silver firs, has become feasible owing to market developments. Where formerly the isolated deodar in the blue pine and spruce forests were removed and the inferior species left untouched, it is now practicable to work through selected areas of mixed conifer forest with the double object of felling inferior timber for the market and encouraging the deodar to spread. In the selection of such areas a sound knowledge of deodar ecology can be of undoubted value to the forest officer.

(c)/

(c) FIRES.

Prior to the protective measures of 1864, the spread of forest was checked by the annual burning of large areas of ground above and around all villages, and many forest areas which the early timber pirates had felled were further reduced by burning. Since the entry of the Forest Department, however, fires have diminished and the areas burned over as village fodder grounds are strictly limited to true grass-lands. It is largely owing to this action that the blue pine has spread and has now formed fine young pole crops over much ground which was previously waste.

The danger of accidental forest fires is not so serious as it is in the outer foothills, but it is still present and requires constant vigilance in the dry seasons in May - June and October - November, the deodar-blue pine of the moist zone and the high level blue pine of the dry and arid zones suffering most from such outbreaks.

In the dry atmosphere of the upper valley natural decay is a very much slower process than in the monsoon zone, and in order to reduce the quantity of inflammable felling and sawing debris, controlled burning has to be undertaken in most felling areas. Such burning causes considerable alterations in the ecological balance of the flora, apart from the impetus/

impetus which the deodar seedling receives from a mixture of wood ash in the soil.

CHAPTER V.

DISTRIBUTION OF FORESTS.

Various species of forest tree, of which the deodar (Cedrus Deodara, London) is the most valuable and the most numerous, combine to form a broad belt along both sides of the Sutlej valley between the cliffs of the gorge below and the alpine pastures and eternal snows above. This is continued in each of the many tributary valleys, and in fact persists in the shelter of the side-streams of the upper Sutlej after it has ceased or become sporadic in the main valley.

The forest types of Kanawar fall naturally into three main divisions, as follows:-

I. A MOIST ZONE in the lower valley, where deodar occurs on the drier and warmer ridges, generally scattered amongst other species. This extends from Rampur to Nichar along 30 miles of the Sutlej valley and contains some 47,000 acres of forest.

II/

II. A DRY ZONE in middle Kanawar where the deodar reaches its optimum development and forms large areas of pure forest. This extends 20 miles up the Sutlej from Nichar to the Chini cliffs and contains some 33,000 acres, including the Baspa Valley with 16 miles of deodar-bearing forest.

III. AN ARID ZONE in the further parts adjoining the Tibetan border where the deodar develops well only on cool aspects and at higher elevations than elsewhere. Forest area : 28,000 acres, stretching along a further 30 miles of the Sutlej valley.

It is now proposed to give a short description of the forests in each of these zones, followed by a more detailed analysis of each of the trees which are found in association with the deodar, and concluding with lists of the vegetation associated with each type of forest.

I./

I. MOIST ZONE FORESTS.

These comprise the Taranda Range forests along the main valley with the Manglad and Soldang as the important valleys to the south, and on the north Pandrabis Range with five long deep parallel glens running up to the Spiti-Sutlej watershed (the Kandrad, Ganwi, Kut, Shorang and Keuncha Gads).

On the left side of the valley which has a northern exposure the forests come much lower down towards the river than they do on the right bank where the insolation of direct sunlight is a potent factor in restricting the spread of vegetation of any kind. Where the same species occurs on opposite sides it comes in on the hot right bank at a very much higher level than it does on the cooler left one, and the two sides of the valley thus have a very dissimilar appearance. On the Taranda side the forests are practically continuous from the riverside at 3,500 feet to the alpine pastures at 12,000 feet, except for a large cultivated area around Sarhan, the summer capital of the Raja of Bashahr, and a belt of village lands at 5,000 - 6,000 feet towards Nichar. The Manglad Gad forests are very similar to the adjoining Lower Bashahr areas, and are in fact/

fact typical of many of the less valuable forest tracts of the outer hills. Beyond Sarhan, however, the deodar-bearing capacity of the forests improves.

On the right bank the main valley slopes of Pandrabis consist largely of hot grass-lands, and it is only in the higher parts that definite forest belts are formed. In the deep and narrow glens of the side-streams, however, forest is well developed on the same lines as in Taranda, but producing much finer deodar. Towards the head of each glen where there is increased shelter from the hot blasts of the Suttlej gorge, most species tend to drop to lower elevations than they frequent near the main valley.

On the lower slopes the chil pine (Pinus longifolia, Roxb.) occupies large areas of open hillsides as a pure crop and gives way to ban oak (Quercus incana, Roxb.) and Rhododendron arboreum, Sm. on more sheltered ravine banks. In the upper part of the chil belt, blue pine (Pinus excelsa, Wall.) and deodar gradually come in, and on warm aspects the blue pine forms extensive forests at 5,000 - 7,000 feet in Taranda. On colder aspects the spruce (Picea Smithiana, Boiss.) is the dominant species with an assorted mixture of broad-leaved species in the damper ravines, the spruce occupying the/

the intermediate ground and forming the bulk of this belt. The deodar is found in occasional patches of pure forest at the level of the blue pine, and extends upwards as scattered trees on the rockier ridges in the spruce ground, and downwards as individual trees amongst the ban oak and the higher chil pine.

The upper forests consist of spruce and silver fir (Abies Pindrow, Spach.) which in Pandrabis merge into a top belt of the kharsu oak (Quercus semecarpifolia, Sm.) below the alpine pastures. In Taranda the kharsu oak does not form pure forest to the same extent. The moist zone formations can thus be summarised as follows:-

<u>TYPE.</u>	<u>LEFT BANK.</u>	<u>RIGHT BANK</u>
i. Chil pine	3500-6000 ft	4500-7000 ft
ii. <u>Ban-oak-Rhododendron</u>	5500-7000 "	6000-7000 "
iii. Blue pine-deodar	5000-7000 "	7000-8500 "
iv. Spruce	7000-10000"	8500-9500 "
v. Broad-leaved mixture	7000-11000"	7000-10000"
vi. Silver fir- <u>kharsu</u> oak	10000-12000"	9500-11000"
vii. Seral communities of moist zone.	- -	- -

II./

II. DRY ZONE FORESTS.

This zone includes the drier eastern end of the Pandrabis and Taranda Ranges, the whole of Kilba including the Baspa Valley and the western parts of the Chini and Kailas Ranges. On the southern left bank the major streams are the Panwi Gad which drains from the Shathul Pass to Wangtu, the Duling Gad which holds the Lishnam forests, the Baspa draining the Nela and Nithal Glaciers on the Tehri Garhwal boundary, and in Kailas a number of smaller torrents draining from the glaciers of the Kanawar Kailas group. On the north bank the important side-streams are the Bhabba or Wangar, the Yula, and the Runang.

On the left bank the forests again form a continuous belt throughout this zone, broken only by the stupendous cliffs of the Kailas group which are devoid of forest along part of the Baspa right bank. On the north of the Suttlej the forest belt is not by any means a continuous feature as there are frequent gaps formed by rock screes and cliffs.

In this zone the low level forest rôle is taken over by the neoza pine (Pinus Gerardiana, Wall.) which/

which forms a very open forest along both banks, mingling on the left bank with the Ilex oak (Quercus Ilex, Linn.) which replaces the ban as a low level oak. Above these the deodar forms pure forest throughout the greater part of this area, mingling in the upper part of its belt with spruce and blue pine. With the decrease in the monsoon rainfall the blue pine alters its level to profit by the long-lying snow in the inner ranges and retreats to 10,000-12,000 feet, replacing the silver fir as the typical subalpine species on the right bank, and mingling with spruce and fir on the left bank. It only appears as a low level species round about Nichar and again in some of the Baspa forests, and elsewhere it appears sporadically amongst the deodar.

In this zone also the spruce gradually retreats to the more sheltered side-valleys and it also retires uphill from a lowest level of 7,000 feet in Panwi Gad to a lowest level of 9,500 feet in the eastern end.

Apart from the belt of Ilex oak and some scrub species associated with it at low levels, the broad-leaved forest is restricted very closely to ravine banks and seldom occupies any appreciable area.

The/

The dry zone forests can be summarised as follows:-

<u>TYPE.</u>	<u>LEFT BANK.</u>	<u>RIGHT BANK.</u>
viii. <u>Ilex oak-neoza</u> pine.	5000-8000 ft	6500-9000 ft
ix. Dry zone deodar	7000-10000 "	8000-10000 "
x. Silver fir-blue pine.	9000-12000 "	9500-11500 "

III. ARID ZONE FORESTS.

This zone includes the remainder of Chini and Kailas Ranges east of Chini and Shongtong villages up to the junction of the Spiti and the Sutlej, near which the last deodar occurs in two small forests on the left bank at Dubling.

The forest here continues in an unbroken belt on the left bank of the Sutlej up to the Tidong Gad and for some five miles up both sides of that valley. Beyond this there are some isolated patches of forest in the Nisang Gad and at Dubling. On the right bank the Chini Range forests form a continuous belt much further up and there are areas of marketable deodar in the Teti Gad, and quite extensive blocks/

blocks of open forest of neoza, deodar, and a little blue pine in the valley of the Ropa Gad which drains from the Manirang Pass on the Spiti border.

With the river bed at a level of over 7,000 feet, and intensely arid conditions, the neoza pine persists as a low level species and also extends right up to alpine levels in certain places, while the deodar only reaches its best development at 9,000-10,000' in the Tidong-Purbani belt. The blue pine continues as a high level species above the deodar and covers extensive areas of the alpine uplands with a scattered tree crop mixed with juniper cushion-scrub.

The differences between the two sides of the valley are not constant in the arid zone, and the various species occur at approximately equal levels on both sides, the southern aspects being frequently devoid of tree growth altogether:-

Arid Zone Forests.

<u>Type.</u>		
xi.	Arid zone <u>neoza</u> pine.	7,500 - 11,000 ft.
xii.	" " deodar	8,500 - 10,500 "
xiii.	" " blue pine	10,000 - 12,000 "
xiv.	Seral communities of dry and arid zones.	

CHAPTER VI.

DESCRIPTION OF MOIST ZONE FORMATIONS.

(i) CHIL PINE BELT.

Pinus longifolia, the chil pine, is the dominant feature of the lower forest belt of the outer hills, but its growth falls off as soon as the monsoon weakens. Its distribution is limited strictly to the area of the effective monsoon, and in the Sutlej valley the last chil pine occurs just six miles beyond Nichar.

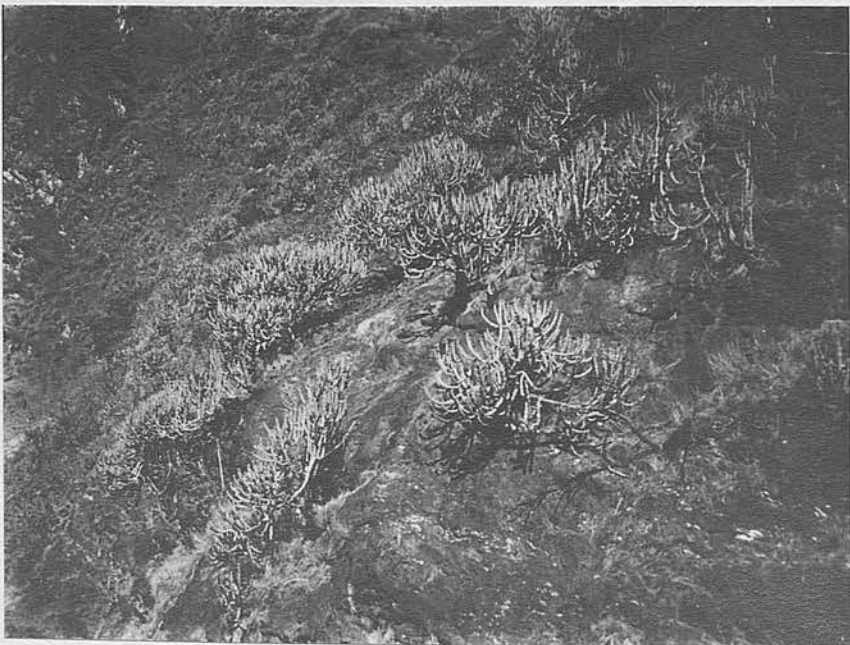
Regular stands of chil are well developed in Lower Bashahr and along the Sutlej up to Taranda, while on the hot southern aspect of the gorge they stop lower down the valley at Jakri, reappearing inside most of the Pandrabis glens on more sheltered aspects. For some miles beyond these points the chil continues as scattered clumps in the hot grass lands until eventually its rôle is taken over by Pinus Gerardiana.

Along the bottom of the chil belt there is invariably a hot bushy scrub growth consisting of such/



FOREST TYPES:- PINUS LONGIFOLIA.

- (19) Chil pine with occasional deodar at 6,500 feet in Kandrad.
Gad, one of the Pandrabis glens.
- (20) Euphorbia Royleana on hot cliffs of southern exposure at
5,000 feet in the chil pine belt.



such bushes as Desmodium nutans, Rhus Cotinus, Mallotus philippinensis, Plectranthus rugosus, and Buddleia paniculata. On the hot cliffs of the north bank there is a scattered growth of prickly pear (Euphorbia Royleana) up to as high as 5,200 feet on ground too hot and rocky even for chil pine, though the two are frequently found together wherever the chil can find a modicum of soil. The Euphorbia, however, is seldom seen on the colder Taranda bank.

8/ this is to be printed in the name "prickly pear" should not be used. D.B.

On certain aspects which yield some shelter from the scorching down-valley wind, some of the larger trees of the foothill forests penetrate up the valley and form small associations of their own, viz:- Dalbergia Sissoo, Cedrela Toona, Sterculia villosa, Lannea grandis, Bauhinia variegata, and Albizzia Julibrissin. A peculiar type of vegetation is the wild banana (Musa rosacea, Jacq.), clumps of which occur at a few places near the river, marking the sites of hot springs, while the only fern of the riverside rocks is Adiantum lunulatum.

Under open stands of chil, Pistacia integerrima is common as a low squat tree, amongst a fairly dense bush growth of Woodfordia floribunda, Rhus Cotinus, Buddleia paniculata, Desmodium sambuense and D. concinnum, Rubus ellipticus and occasional/

occasional socies of Lilium Thomsonianum in heavy grass clumps. Higher up and under a more regular canopy bush growth is less rampant and here Desmodium, Berberis, Rhyncosia pseudocajan, Myrsine africana, Indigofera pulchella, and Caryopteris Wallichiana are found, with Plectranthus ubiquitous, and Lespedeza and Compositae as the common herbs.

On the hotter north bank pole crops dense enough to kill out undergrowth are not common, but scattered chil reaches an enormous girth in the Pandrabis grass-lands, several trees of over 10 feet girth and one of $14\frac{1}{2}$ feet occurring near the Keuncha Gad mouth. Such places wherever the soil is stable have a ground flora of Andropogon and Eragrostis grasses, Salvia Moorcroftiana and lanata, Androsace rotundifolia, Lactuca dissecta, and Oxalis corniculata, but very little shrub growth, presumably owing to the enormously heavy winter grazing incidence on these slopes which are always the first to be free of snow.

The pure chil belt extends uphill to 6,500 or even 7,500 feet on such dry hillsides, but on the more sheltered aspects and in ravines it is replaced much lower by the ban oak - Rhododendron formation. It gradually merges into this and into the blue pine-deodar/

pine-deodar belt above. The ban oak comes in wherever the aspect gets round towards the north and its entry is generally heralded by an increase of Caesalpinia sepiaria both as a shrub and a climber, Clematis and Rosa moschata as climbers, and a bushier growth of shrubs such as Deutzia staminea, Spiraea Lindleyana, Asparagus adscendens, Roylea calycina, and herbs such as Strobilanthes glutinosus and Valeriana Wallichii. The blue pine and deodar on the other hand come in more frequently on the open hillsides, and their appearance is indicated by an increase in the amount of Cedrela serrata, Elscholtzia polystachya, Coriaria nepalensis, Prinsepia utilis, Jasminum humile, and Spiraea canescens in the shrubs, and Smilax, Fragaria, and Viola in the ground cover.

CHIL/

CHIL PINE BELT VEGETATION LIST.

A. TREES.

(a) Lower Scrub Associations.

Albizzia Julibrissin, Durazz.
Bauhinia variegata, Linn.
Cedrela Toona, Roxb.
Dalbergia Sissoo, Roxb.
Erythrina glabrescens, Parker.
Euphorbia Royleana, Boiss.
Ficus Roxburghii, Wall.
Lannea grandis, Engl.
Melia Azedarach, Linn.
Musa, rosacea, Jacq.
Pinus longifolia, Roxb.
Punica granatum, Linn.
Sterculia villosa, Roxb.

(b) Chil Pine Associations.

Cedrela serrata, Royle
Cedrus Deodara, Loudon.
Pinus longifolia, Roxb.
Pinus excelsa, Wall.
Pistacia integerrima, Royle
Quercus incana, Roxb.
Rhododendron arboreum, Sm.

B. SHRUBS.

(a) Lower Scrub Associations.

Artemisia vulgaris, Linn.
Buddleia paniculata, Wall.
Colebrookia oppositifolia, Sm.
Desmodium nutans, Wall.
Debregeasia hypoleuca, Wedd.
Indigofera Gerardiana, var. *heterantha*,
 Wall.
Mallotus philippinensis, Muell.
Osbeckia/

(a) Lower Scrub Associations contd.

Osbeckia stellata, Wall.
Plectranthus rugosus, Wall.
Rhus Cotinus, Linn.
Sageretia theezans, Brongn.
Symplocos crataegoides, Buch-Ham.
Zanthoxylum alatum, Roxb.
Zizyphus rotundifolia, Lam.
 " *oxyphylla*, Edgew.

(b) Chil Pine Associations.

Andrachne cordifolia, Muell.
Asparagus adscendens, Roxb.
Berberis petiolaris, Wall.
 " *Lycium*, Royle.
Caryopteris Wallichiana, Schau.
Desmodium concinnum, DC.
 " *nutans*, Wall.
 " *oxyphyllum* DC.
 " *sambuense*, DC.
Deutzia staminea, R.Br.
Elaeagnus umbellata, Thunb.
Flemingia fruticulosa, Wall.
Hamiltonia suaveolens, Roxb.
Indigofera Gerardiana
 var. *heterantha*, Wall.
 " *pulchella*, Roxb.
Inula Cappa, DC.
Leptodermis lanceolata, Wall.
Lonicera angustifolia, Wall.
 " *quinquelocularis*, Hardw.
Meriandra strobilifera, Benth.
Micromeria biflora, Benth.
Myrsine africana, Linn.
Plectranthus rugosus, Wall.
Prinsepia utilis, Royle
Rhus Cotinus, Linn.
Rhyncosia pseudocajan, Camb.
Roylea calycina, Briquet.
Rubus ellipticus, Sm.
 " *paniculatus*, Sm.
Scutellaria repens, Buch-Ham.
Spiraea canescens, D.Don.
Woodfordia floribunda, Salisb.

C. HERBS.

(a) Common to Low Scrub and Chil Pine.

Anaphalis adnata, DC.
 " *araneosa*, DC.
Androsace rotundifolia, Hardw.
Aster asperulus, Nees.
Echinops niveus, Wall.
Lespedeza sericea, Benth.
Salvia lanata, Roxb.
 " *Moorcroftiana*, Wall.
 " *glutinosa*, Linn.
Senecio nudicaulis, Buch-Ham.

(b) Low Scrub Associations only.

Cannabis sativa, Linn.
Commelina obliqua, Buch. - Ham.
Crepis japonica, Benth.
Cyathula tomentosa, Moq.
Datisca cannabina, Linn.
Datura Stramonium, Linn.
Diclyptera bupleuroides, Nees.
Justicia simplex, D. Don.
Laggera alata, Sch.
Lychnis indica, Benth.
Pimpinella diversifolia, DC.
Primula floribunda, Wall.
Saussurea obvallata, Wall.
Teucrium quadrifarium, Buch-Ham.

(c) Chil Pine Associations Only.

Aechmanthera tomentosa, Nees.
Androsace lanuginosa, Wall.
Gonyza japonica, Less.
Gnaphalium hypoleucum, DC.
Lactuca dissecta, D. Don.
Lathyrus sphaericus, Retz.
 " *pratensis*, Linn.
Leucas lanata, Benth.
Lilium Thomsonianum, Lindl.
Lotus corniculatus, Linn.
Nepeta linearis, Royle.
Oxalis corniculata, Linn.
Polygala/

(c) Chil Pine Associations only. contd.

Polygala abyssinica, R. Br.
 " *chinensis*, Linn.
Rhynchosia himalensis, Benth.
 " *sericea*, Span.
Sonchus arvensis, Linn.
Strobilanthes glutinosus, Nees.
Verbena officinalis, Linn.

D. GRASSES. (Common to Whole Belt).

Andropogon Ischaemum, Linn.
 " *Gryllus*, Linn.
 " *contortus*, Linn.
Apluda aristata, Hack.
Anthraxon submuticus, Hochst.
Avena fatua, Linn.
Cynodon Dactylon, Pers.
Eragrostis nigra, Nees.
Lolium temulentum, Linn.
Pollinia quadrinervis, Hack.

E. FERNS. (Low Scrub Associations only).

Adiantum lunulatum, Burn.

(ii) BAN OAK - RHODODENDRON FORMATION.

Quercus incana, the ban oak, is the common low level oak of the moist zone, and is the major species over considerable areas of ground from 5000 up to 8000 feet. It thus overlaps into the altitudinal zones of all the lower conifers, and is a common companion of the blue pine, deodar, and spruce, as well as the chil. In the upper part of the chil belt, however, it is really the main forest-forming species, and combines with Rhododendron arboreum to form broad-leaved forest on ground too damp or too cold for chil pine, while on common ground the three combine to form a two-storeyed forest of open chil stands with an oak-Rhododendron underwood, Pieris ovalifolia being almost as common as Rhododendron in some places. On damp ravine banks there is a tendency for other broad-leaved species to come in as forerunners of the mixed broad-leaved forest discussed under type v below, the first being Cedrela serrata, Acer pictum, Rhus semialata, Prunus cornuta, Pyrus Pashia, and further up Ulmus laevigata, Celtis australis and Corylus Colurna, while Alnus nitida is found anywhere near flowing water, and blue pine and deodar occur sporadically on the drier ground towering high above the mass of deciduous species/

species.

Shrubs and climbers are best developed where conifers break the oak and Rhododendron canopy, while under dense and continuous broad-leaved shade the shrubs frequently give place to herbs, mixed in the upper levels with a few ferns. The common climbers are Clematis, Rosa moschata, and Caesalpinia sepiaria. The common shrubs in the rampant scrub associated with an open canopy and an admixture of blue pine and deodar are:- Berberis, Rhamnus, Piptanthus, Desmodium, Prinsepia, Rubus, and Deutzia in the deeper ravines, and on colder aspects the shrubs are Skimmia, Ribes rubrum, Machilus, Litsea, Daphne papyracea and Sarcococca, and these are typical of the upper oak stands where Quercus dilatata tends to replace Quercus incana and where the accompanying conifers are spruce and an occasional deodar. The somewhat rank herbaceous growth of damp ravine bottoms consists largely of Valeriana Hardwickii, Bidens bipinnata, Senecio, Scrophularia, Hedychium and Arisaema, and it is in such places that the Arundinaria bamboo first appears as isolated clumps.

BAN/

BAN OAK-RHODODENDRON VEGETATION LIST.

A. TREES.

Acer caesium, Wall.
Acer pictum, Thunb.
Alnus nitida, Endl.
Cedrela serrata, Royle.
Cedrus Deodara, Loudon.
Celtis australis, Linn.
Cornus macrophylla, Wall.
Corylus Colurna, Linn.
Ficus foveolata, Wall.
Meliosma dilleniaefolia, Walp.
Picea Smithiana, Boiss.
Pieris ovalifolia, D.Don.
Pinus excelsa, Wall.
Pinus longifolia, Roxb.
Prunus cornuta, Wall.
Pyrus Pashia, Buch-Ham.
Quercus incana, Roxb.
 " *dilatata*, Lindl.
Rhododendron arboreum, Sm.
Rhus semialata, Murr.
Rhus Wallichii, Hk.
Salix tetrasperma, Roxb.
Ulmus laevigata, Royle.

B. SHRUBS.

Berberis petiolaris, Wall.
 " *Lycium*, Royle.
Buddleia paniculata, Wall.
Cotoneaster bacillaris, Wall.
Daphne papyracea, Decne.
Desmodium sambuense, DC.
 " *podocarpum* DC.
Deutzia staminea, R.Br.
 " *corymbosa*, R.Br.
Eupatorium cannabinum, Linn.
Flemingia strobilifera, R.Br.
Indigofera hebeptala, Benth.
Inula cuspidata, Clarke.
Litsea umbrosa, Nees.
Machilus Duthiei, King.
Picrasma quassioides, Benn.
Piptanthus/

B. SHRUBS Contd.

Piptanthus nepalensis, Sweet.
Prinsepia utilis, Royle.
Rhamnus purpurea, Edgew.
Ribes rubrum, Linn.
Rosa macrophylla, Lindl.
Roylea calycina, Briquet.
Rubus paniculatus, Sm.
Rubus ellipticus, Sm.
Sarcococca saligna, Muell.
Skimmia Laureola, Sieb.
Spiraea Lindleyana, Wall.
Viburnum cotinifolium, D. Don.

C. HERBS.

Arisaema intermedium, Blume.
Asparagus filicinus, Buch-Ham.
Begonia picta, Sm.
Bidens bipinnata, Linn.
Craniotome versicolor, Reichb.
Fragaria vesca, Linn.
Hedychium spicatum, Sm.
Leucas lanata, Benth.
Nepeta leucophylla, Benth.
Parochetus communis, Buch-Ham.
Rhyncosia sericea, Span.
Scrophularia himalensis, Royle.
Senecio alatus, Wall.
 " *rufinervis* DC.
Valeriana Hardwickii, Wall.
 " *Wallichii*, DC.
Viola Patrinii, Ging.
 " *serpens*, Wall.

D. CLIMBERS.

Caesalpinia sepiaria, Roxb.
Clematis barbellata, Edgew.
 " *connata*, DC.
Ilex dipyrena, Wall.
Periploca calophylla, Falc.
Rosa moschata, Herrm.
Trachelospermum fragrans, Hk.
Vallaris Heynei, Spreng.
Vitis capreolata, D. Don.

*I only know this species
 as a tree*
 J. P.

E. GRASSES./

E. GRASSES.

Arundinaria falcata, Nees.
Erianthus fulvus, Nees.
Panicum plicatum, Lam.
Pennisetum flaccidum, Griseb.
Pollinia quadrinervis, Hack.

F. FERNS.

Asplenium aristatum, Sm.
Aspidium maximum, Don.
Nephrodium Boryanum, Baker.

(iii) BLUE PINE-DEODAR BELT.

Pinus excelsa, the blue pine or kail, is second only to deodar in its importance as a commercial timber, and it accompanies the deodar throughout the whole field of the latter's distribution. The blue pine has two altitudinal zones which are well defined, although the tree is quite common on intermediate ground between these two habitats. The low level form, depending on a moderately good monsoon rainfall, is well developed in the Simla Hills and Lower Bashahr although it avoids the excessively wet outer hills of Kangra. The high level type is dependent on a heavy and long-lying winter snowfall and is confined to the upper forest limits in the inner hills. Between 5,000 - 7,000 feet in Taranda Range and 6,000 - 8,000 feet in the Pandrabis glens the low level blue pine combines with deodar to form a definite belt of forest. The occurrence of the blue pine, in dense pole stands over so much of this area, is due to the cessation of extensive burning by the villagers since these forests came under the care of the Forest Department. This species is a wonderful coloniser and has established itself over large areas during the last 70 years. Of all the larger/





BLUE PINE as a PIONEER SPECIES.

- (21) Landslip in Kut Gad being reoccupied by a heavy crop
of blue pine seedlings.
- (22) Pine seedlings established in deserted cultivation;
Ganwi Gad forests.



larger tree species of the moist zone the blue pine is undoubtedly the nearest to the deodar in its ecological requirements and in its love for a warm well-drained soil, hence the deodar is following the pine and establishing itself in ever-increasing numbers in this belt, assisted, of course, by judicious thinnings and cleanings under the Working Plan prescriptions.

In the western end of Taranda Range, i.e. Manglad Gad, - the deodar displaces the blue pine in only a few places and forms small patches of pure forest on some south-eastern slopes, but more commonly it occurs as occasional single trees and small groups on the rockier spurs of the blue pine forest. In the eastern half of Taranda Range, however, the quantity and quality of the deodar improves perceptibly, and larger stands of pure deodar occur, owing presumably to a reduction in the rainfall beyond the Maniotidhar, where a great spur of the Dhauladhar Range and an eastward bend of the valley both serve to stop the monsoon clouds in their course up the valley. In Pandrabis, however, the higher Spiti watershed attracts a heavier rainfall and the deodar continues to cling to the rocky spurs. Here there is a much larger area of such rocky spurs with a/

a warm aspect where the deodar develops to an enormous size, the blue pine keeping more to the gentle slopes between the spurs, and being replaced at higher levels and on colder aspects by the spruce.

Of the oaks, Quercus dilatata, the moru oak, is the commonest in this blue pine-deodar belt. It is not such a prominent feature in Bashahr as either Quercus. seme-carpifolia or Ilex, as it is more or less restricted to this particular type of forest. Beyond Nichar it is only met with occasionally, and in the dry zone the oak rôle is taken on by Quercus Ilex. The moru oak replaces the ban as an underwood in the blue pine belt, except where heavy lopping of the moru has driven it out. In this type of forest the ground is usually very clear of shrubby growth under a close canopy of either deodar or blue pine, only occasional small bushes of Indigofera Gerardiana, Spiraea canescens, Rosa macrophylla, Jasminum, and Daphne papyracea being found amongst a more regular herb covering of Viola, Fragaria, Smilax, Thalictrum, Gerbera, Ajuga and maidenhair fern (Adiantum). Wherever the canopy thins out a heavier shrub growth of Plectranthus, Berberis, Prinsepia, Desmodium tiliacifolium, Rubus, and some of the coarser Compositae come in.

Towards/

Towards the upper level of the blue pine the bracken (Pteris aquilina) fills up the open glades and Iris nepalensis also forms large patches. Both of these species are so dense that they exclude other ground herbage completely.

BLUE/



MOIST ZONE DEODAR.

- (23) 24-year old deodar plantation at Taranda,
average height, 16 feet.
- (24) Panwi and Dippi forests in Taranda Range; gentle slopes
on right mostly blue pine; steeper spurs on left mostly
deodar.



.BLUE PINE - DEODAR BELT VEGETATION.

A. TREES.

Cedrela serrata, Royle.
Cedrus Deodara, Loudon.
Euonymus Hamiltonianus, Wall.
 " *tingens*, Wall.
Picea Smithiana, Boiss.
Pinus excelsa, Wall.
Prunus cerasoides, D.Don.
 " *persica*, Stokes.
Quercus dilatata, Lindl.
 " *incana*, Roxb.

B. SHRUBS.

Abelia triflora, R.Br.
Artemisia vulgaris, Linn.
Berberis Lycium, Royle.
 " *petiolaris*, Wall.
Caragana brevispina, Benth.
Coriaria nepalensis, Wall.
Cotoneaster bacillaris, Wall.
Daphne papyracea, Decne.
Desmodium tiliaefolium, G.Don.
Deutzia staminea, R.Br.
Elscholtzia polystachya, Benth.
Hypericum cernuum, Roxb.
Indigofera Gerardiana, Wall.
Jasminum humile, Linn.
Lonicera angustifolia, Wall.
 " *quinquelocularis*, Hardw.
Plectranthus rugosus, Wall.
Prinsepia utilis, Royle.
Rhamnus dahurica, Pall.
Rosa macrophylla, Lindl.
 " *sericea*, Lindl.
Rubus biflorus, Buch-Ham.
 " *niveus*, Wall.
Smilax parviflora, Wall.
 " *vaginata*, Decne.
Spiraea canescens, D.Don.

C. HERBS/

C. HERBS.

(a) Usually confined to pure blue pine:-

Arisaema intermedium, Blume.
 " *Wallichianum*, Hk.
Chaerophyllum villosum, Wall.
Polygonum molle, D.Don.

(b) Common to both blue pine and deodar:-

Ainsliaea aptera, DC.
Anaphalis nubigena DC.
Ajuga parviflora, Benth.
Asparagus filicinus, Buch-Ham.
 " *gracilis*, Royle.
Boenninghausenia albiflora, Reichb.
Bupleurum falcatum, Linn.
Campanula latifolia, Linn.
Fragaria vesca, Linn.
Gentiana argentea, Royle.
Gerbera lanuginosa, Sch.
Gnaphalium luteo-album, Linn.
Iris nepalensis, D.Don.
Lactuca dissecta, D.Don.
Mertensia racemosa, Benth.
Nepeta spicata, Benth.
Prenanthes Brunoniana, Wall.
Primula denticulata, Sm.
Roscoea eliator, Sm.
Salvia glutinosa, Linn.
Satyrium nepalense, D.Don.
Saxifraga ligulata, Wall.
Senecio alatus, Wall.
 " *pedunculatus*, Edgew.
Taraxacum officinale, Wigg.
Thalictrum foliolosum DC.
 " *javanicum*, Blume.
 " *minus*, Linn.
Tragopogon gracilis, D.Don.
Urtica dioica, Linn.
Valeriana Wallichii, DC.
Vicia tenera, Grah.
Vigna capensis, Walp.
Viola Patrinii, Ging.
Viola serpens, Wall.

D. CLIMBERS/

D. CLIMBERS.

Clematis Buchananiana DC.
 " *connata*, DC.
 " *montana*, Buch-Ham.
Discorea deltoidea, Wall.
 " *melanophyma*, Prain.
Ilex diphyrena, Wall.
Rosa moschata, Herrm.
Vitis divaricata, Wall.

E. GRASSES.

Agropyron longearistatum, Boiss.
Agrostis alba, Linn.
Agrostis Royleana, Trin.
Andropogon Gryllus, Linn.
 " *tristis*, Nees.
Avena aspera, Munro.
Calamagrostis littorea, DC.
Dactylis glomerata, Linn.
Poa pratensis, Linn.
Spodiopogon dubius, Hack.

F. FERNS.

Adiantum Capillus-Veneris, Linn.
 " *venustum*, Don.
Aspidium aristatum, Sw.
Asplenium maximum, Don.
 " *nigripes*, Blume.
Nephrodium Boryanum, Baker.
Pteris aquilina, Linn.

(iv) SPRUCE-DEODAR BELT.

The bulk of the north-facing slopes from 7,000 to 10,000 feet in the moist zone carry a fairly dense forest of spruce (Picea Smithiana) with a varying admixture of deodar. In the west end the deodar is restricted and only appears occasionally in the lower half of the spruce belt in Manglad Gad in groups of two or three trees on the crowns of rocky spurs. Towards the east in Taranda Range and throughout Pandrabis both on the main Suttlej face and in the side valleys it is more in evidence, occurring sporadically in the damper spruce ground on cold slopes as well as dominating the drier spurs. On the warmer aspects also the blue pine continues dominant, and in many places up to 8,500 feet the three species occur together, while in eastern Pandrabis the blue pine runs right up into the upper oak belt, displacing the spruce altogether in some south and south-east aspects. With the falling off in the monsoon in the eastern end of the Bashahr moist zone the spruce definitely abandons the ridges and is confined to the colder slopes.

Under the spruce the two lower oaks

(Quercus/



FOREST TYPES:- SPRUCE - DEODAR BELT.

- (25) Spruce on side slopes and deodar on steepest spurs;
Rushnang forest in Bhabba valley.
- (26) Open crop of spruce and deodar in foreground; Taranda and
Chaunda Gad forests in middle distance.



(Quercus incana and dilatata) are both common though they are seldom mixed, one or other being locally in evidence to the exclusion of the other, while towards the top of the spruce belt the kharsu oak (Quercus semecarpifolia) and the silver fir (Abies Pindrow) come in, forming a mixture with the spruce over large areas at 9,000 to 11,000 feet.

Other broad-leaved trees such as Euonymus and Acer are fairly common as undergrowth and generally mark the change from the flora of the windswept ridges to the more sheltered hollows where the broad-leaved thach forest excludes the conifers entirely.

On the drier ridges where deodars are fairly frequent the bushes are Lonicera quinquelocularis, Indigofera Gerardiana, Berberis Lycium, Rubus spp., Caragana brevispina, Prinsepia, Piptanthus and Spiraea canescens, and the herbs are Fragaria, Viola, Primula denticulata, and Valeriana Wallichii, with bracken fern and Spiraea Lindleyana in blanks.

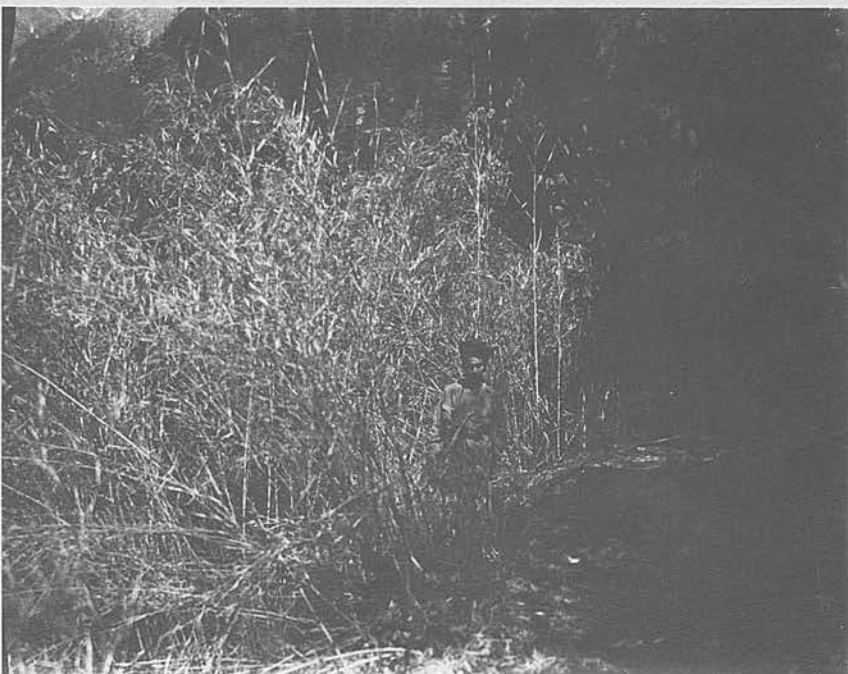
On the intermediate slopes between ridges and ravines the ringal bamboo (Arundinaria falcata) is often the only ground cover because its dense shade and masses of vegetation crowd out everything else, frequently choking out deodar and spruce regeneration.

Elsewhere/



MOIST ZONE DEODAR.

- (27) Deodar sapling crop established under old blue pine forest; broad-leaved thach in distance; Ganwi Gad, 8,000 feet.
- (28) Dense masses of Arundinaria bamboo render deodar reproduction difficult in Pandrabis spruce-deodar belt.



Elsewhere on these slopes where deodar occasionally manages to penetrate amongst the spruce there is generally a mass of straggling trees and bushes such as Pyrus Pashia, Deutzia corymbosa, Ribes rubrum, Viburnum nervosum, Cotoneaster acuminata, Euonymus, and Acer, with a variety of creepers such as Schizandra, Clematis, Vitis and Solanum Dulcamara. The ground flora is very varied in this type of forest and contains Ainsliaea aptera, Primula petiolaris, Thalictrum reniforme, Corydalis, Spiraea vestita and Spiraea Aruncus, Chaerophyllum, Wulfenia Amherstiana, and Polygonatum species, while among ferns Aspidium and Polypodium species are commoner than Adiantum. Strobilanthes often occupies large areas to the complete exclusion of any other ground plants and less commonly is mixed with Impatiens.

Towards the top of the spruce belt where the percentage of silver fir and kharsu oak increases the yew (Taxus baccata) and the birch (Betula alnoides) come in, the yew often suppressing any vegetation in its shade. The common shrubs here are Skimmia, Viburnum nervosum, and Strobilanthes, and the herbs are Polygonum, Allium, Trillium, and Fritillaria, while the Nephrodium ferns are much commoner/

commoner than those mentioned in the lower belts.

Wet rock faces are occupied by Saxifraga ligulata and Sedum species, while rock screes in the damper spruce areas are first populated with Girardinia, Pilea, Leonurus and Cannabis.

SPRUCE-DEODAR VEGETATION LIST.

A. TREES.

Abies Pindrow, Spach.
Acer acuminatum, Wall.
 " *caesium*, Wall.
 " *pictum*, Thunb.
Betula alnoides, Buch-Ham.
Euonymus lacerus, Buch-Ham.
Picea Smithiana, Boiss.
Pinus excelsa, Wall.
Quercus dilatata, Lindl.
Quercus incana, Roxb.
Quercus semecarpifolia, Sm.
Taxus baccata, Linn.

B. SHRUBS.

Astragalus chlorostachys, Lindl.
Berberis Lycium, Royle.
 " *petiolaris*, Wall.
Cotoneaster acuminata, Lindl.
 " *bacillaris*, Wall.
Daphne papyracea, Decne.
Desmodium tiliacifolium, G.Don.
Deutzia corymbosa, R.Br.
Hypericum patulum, Thunb.
Indigofera Gerardiana, Wall.
Jasminum humile, Linn.
Leycesteria formosa, Wall.
Lonicera alpigena, Linn.
 " *orientalis*, Lam.
 " *quinquelocularis*, Hardw.
Piptanthus/

B. SHRUBS Contd.

Piptanthus nepalensis, Sweet.
Rhamnus purpurea, Edgew.
Ribes glaciale, Wall.
 " *rubrum*, Linn.
Rosa macrophylla, Lindl.
Rubus biflorus, Buch-Ham.
 " " *lasiocarpus*, Sm.
 " *niveus*, Wall.
Skimmia Laureola, Sieb.
Spiraea bella, Sims.
 " *canescens*, D.Don.
 " *Lindleyana*, Wall.
Strobilanthes alatus, Nees.
 " *atropurpureus*, Nees.
Viburnum nervosum, D.Don.

C. HERBS.

Ainsliaea aptera, DC.
Allium rubeus, Baker.
 " *Wallichianum*, Steud.
Anaphalis triplinervis, Clarke.
Aralia cachemirica, Decne
Asparagus filicinus, Buch-Ham.
Astilbe rivularis, Buch-Ham.
Boenninghausenia albiflora, Reichb.
Bupleurum lanceolatum, Wall.
Cannabis sativa, Linn.
Carpesium cernuum, Linn.
Chaerophyllum villosum, Wall.
Chirita pumula, D.Don.
Corydalis rutaefolia, DC.
Cyanotis barbata, D.Don.
Dynanchum glaucum, Wall.
Dipsacus strictus, D.Don.
Erigeron multiradiatus, Benth.
Fragaria vesca, Linn.
Fritillaria Roylei, Hk.
Gentiana quadrifaria, Blume.
Girardinia palmata, Gaudich.
Halenia elliptica, D.Don.
Heracleum candidans, Wall.
 " *canescens*, Lindl.
Impatiens Roylei, Walp.
 " *Thomsoni*, Hk.
Lactuca Scariola, Linn.
Lamium amplexicula, Linn.
Leonurus Cardiac, Linn.
Mertensia racemosa, Benth.
Nepeta Govaniana, Benth.
 " *leucophylla*, Benth.
Pilea/

C. HERBS Contd.

Pilea umbrosa, Wedd.
Plantago lanceolata, Linn.
Polygonatum multiflorum, All.
 " *verticillatum*, All.
Primula denticulata, Wall.
 " *petiolaris*, Wall.
Polygonum chinense, Linn.
Roscoea elvætor, Sm.
Saussurea hypoleuca, Spreng.
Saxifraga ligulata, Wall.
Scrophularia calycina, Benth.
Sedum adenotrichum, Wall.
 " *multicaule*, Wall.
 " *rosulatum*, Edgew.
Spiraea Aruncus, Linn.
 " *vestita*, Wall.
Stellaria crispata, Wall.
Swertia cordata, Wall.
 " *purpurascens*, Wall.
Thalictrum reniforme, Royle.
Trillium Govanianum, Wall.
Urtica dioica, Linn.
Valeriana Hardwickii, Wall.
 " *Wallichii*, DC.
Viola Patrinii, Ging.
 " *serpens*, Wall.
Wulfenia Amherstiana, Benth.

D. CLIMBERS.

Clematis barbellata, Buch-Ham.
Hedera Helix, Linn.
Ilex dipyrena, Wall.
Schizandra grandiflora, Hk.
Solanum Dulcamara, Linn.
Vitis lanata, Roxb.
 " *parvifolia*, Roxb.
 " *semichordata*, Wall.

E. GRASSES.

Agropyron longearistatum, Boiss.
Arundinaria falcata, Nees.
 " *spathiflora*, Trin.
Dactylis glomerata, Linn.
Erianthus fulvus, Nees.
Melica scaberrima, Hk.
Oplismenus undulatifolius, Beauv.
Oryzopsis aequiglumis, Duthie.
Pennisetum flaccidum, Griseb.

F. FERNS/

F. FERNS.

Adiantum Capillus-Veneris, Linn.
 " *venustum*, Don.
Aspidium aculeatum, Sw.
 " *ilicifolium*, Don.
 " *Prescottianum*, Hk.
Cheilanthes subvillosa, Hk.
Nephrodium barbigerum, Hk.
 " *Brunonianum*, Hk.
Polypodium amoenum, Wall.
 " *lineare*, Thunb.
Pteris aquilina, Linn.
 " *cretica*, Linn.

. (v) BROAD-LEAVED "THACH" FOREST.

The coldest aspects and all the reentrants and ravine bottoms of the spruce belt (7,000 - 10,000 feet) are entirely occupied by a rich mixture of broad-leaved species to the exclusion of conifers except for scattered spruce and a very occasional deodar. In the Pandrabis glens this type is well developed and spreads uphill in a fan shape from the lower ravines, occupying more and more of the gentle slopes with increased elevation, as the conifers retreat to the better drained ridges.

The oaks are only occasional members of this type, which is commonly known in Bashahr as thach (grazing land) owing to the richness of the shrub/



FOREST TYPES:- BROAD-LEAVED "THACH" FOREST.

- (29) Mixed broad-leaved species occupying hollows and conifers on ridges; Ganwi Gad at 10,000 feet.
- (30) Interior of thach in early spring; Corylus, Cornus, Ulmus, and Acers.



shrub growth and the quantity of loppings which the mixed broad-leaved species provide. The common trees are Acer, Pyrus, Pieris, Rhododendron, Rhus, Celtis, Cornus, horsechestnut, alder, walnut, hazel, elm, bird-cherry, poplar, hornbeam, and less commonly the box, ash and yew. The shrub growth is a mixture of Skimmia, Cotoneaster, Deutzia, Viburnum, Lonicera, Leycesteria, Machilus, Litsea, and Sarcococca. Herb growth is poorly developed except in a few rather specialised types of canopy, - e.g. a dense growth of Chaerophyllum reflexum under a pure stand of Pyrus lanata; Galium, Boenninghausenia, Rubia, Salvia glutinosa, Viola and Adiantum fern under a pure stand of horse-chestnut; and under the very densest of the Corylus-Pyrus stands a herb growth of Viola, Ain^sliaea, and Adiantum instead of shrubs.

BROAD-LEAVED "THACH" FOREST VEGETATION LIST.

A. TREES.

Abies Pindrow, Spach. (Low level Fir).
 " spectabilis, Spach. (High Level Fir).
Acer acuminatum, Wall.)
 " caesium, Wall.) maples.
 " pictum, Thunb.)
 " villosum, Wall)
Aesculus indica, Colebr. (horse-chestnut)
Alnus nitida, Endl. (aldor)
Betula/

A. TREES Contd.

Betula alnoides, Buch-Ham. (birch)
Buxus Wallichiana, Baillon. (box)
Carpinus faginea, Lindl. (hornbeam)
 " *viminea*, Lindl. "
Cedrus Deodara, Loudon, (deodar)
Celtis australis, Linn.
Cornus capitata, Wall.
 " *macrophylla*, Wall.
 " *oblonga*, Wall.
Corylus Colurna, Linn (hazel)
Euonymus Hamiltonianus, Wall.
 " *tingens*, Wall.
Fraxinus micrantha, Lingelsh. (ash)
Juglans regia, Linn (walnut)
Meliosma dilleniaeefolia, Walp.
Pieris ovalifolia, D.Don.
Picea Smithiana, Boiss, (spruce)
Pinus excelsa, Wall (blue pine)
Populus ciliata, Wall. (poplar)
Prunus cornuta, Wall (bird cherry)
Pyrus Aucuparia, Ehrh. (mountain ash)
 " *foliolosa*, Wall.
 " *lanata*, D.Don.
 " *Pashia*, Buch-Ham.
Quercus dilatata, Lindl (moru oak)
 " *incana*, Roxb. (ban oak)
 " *semecarpifolia*, Sm. (kharsu oak)
Rhododendron arboreum, Sm.
Rhus Wallichii, Hk.
Taxus baccata, Linn. (yew)
Ulmus Wallichiana, Baillon) (elm)
 " *laevigata*, Royle.)

B. SHRUBS.

Berberis petiolaris, Wall.
Cotoneaster acuminata, Lindl.
 " *bacillaris*, Wall.
Daphne papyracea, Decne.
Deutzia corymbosa, R.Br.
Eupatorium cannabinum, Linn.
Jasminum humile, Linn.
Leycesteria formosa, Wall.
Litsea umbrosa, Nees.
Lonicera alpigena, Linn.
 " *orientalis*, Lam.
Machilus Duthiei, King.
Polygonum amplexicaule, D.Don.
 " *polystachyum*, Wall.
Rhamnus/

B. SHRUBS Contd.

Rhamnus purpurea, Edgew.
Ribes glaciale, Wall.
Ribes rubrum, Linn.
Rosa macrophylla, Lindl.
Rubus biflorus, Buch-Ham.
 " *lasiocarpus*, Sm.
Sarcococca saligna, Muell.
Skimmia Laureola, Sieb.
Spiraea Lindleyana, Wall.
Strobilanthes alatus, Nees.
 " *atropurpureus*, Nees.
Viburnum nervosum, D. Don.
 " *stellulatum*, Wall.

C. HERBS.

Aconitum heterophyllum, Wall.
 " *Lycocotonum*, Linn.
Ainsliaea aptera, DC.
Allium rubeus, Baker.
Arisaema intermedium, Blume.
Boenninghausenia albiflora, Reichb.
Campanula colorata, Wall.
Cannabis sativa, Linn.
Chaerophyllum reflexum, Lindl.
 " *villosum*, Wall.
Corydalis rutaefolia, DC.
Fritillaria Roylei, Hk.
Galium Aparine, Linn.
Habenaria ensifolia, Lindl.
Impatiens racemosa, DC.
Impatiens scabrida, DC.
Lamium amplexicaule, Linn.
Leonurus Cardica, Linn.
Myriactis Wallichii, Less.
Polygonatum multiflorum, All.
 " *verticillatum*, All.
Polygonum chinense, Linn.
Primula petiolaris, Wall.
Saxifraga ligulata, Wall.
Sedum Ewersii, Ledeb.
 " *rosulatum*, Edgew.
Spiraea Aruncus, Linn.
 " *vestita*, Wall.
Stachys sericea, Wall.
Trillium Govanianum, Wall.
Urtica dioica, Linn.
Valeriana Hardwickii, Wall.
Viola serpens, Wall.

D. CLIMBERS/

D. CLIMBERS.

Hedera Helix, Linn.
 Vitis lanata, Roxb.
 Vitis semichordata, Wall.

E. GRASSES.

Arundinaria falcata, Nees.
 " spathiflora, Trin.
 Melica scaberrima, Hk.
 Oryzopsis aequiglumis, Duthie.
 Pennisetum flaccidum, Griseb.

F. FERNS.

Adiantum Capillus-Veneris, Linn.
 Aspidium aculeatum, Sw.
 " ilicifolium, Don.
 " Prescottianum, Hk.
 Polypodium amoenum, Wall.
 " lineare, Thunb.
 Pteris cretica, Linn.

(vi) KHARSU OAK - SILVER FIR BELT.

Abies Pindrow, Spach and spectabilis, Spach. (Webbiana, Lindl.) have been separated by Parker as the Low Level and High Level Silver Firs respectively, but although the two do occur as quite recognisable botanical types in the Upper Sutlej they do not constitute separate units for ecological work. Together they form a high level forest belt through/

through the moist zone with much the same distribution as the spruce, but replacing the spruce above and forming with the kharsu oak the highest of the altitudinal forest belts, at 10,000 - 12,000 feet in the moist zone.

Quercus semecarpifolia, Sm. the kharsu oak, forms a belt of pure forest on the south-facing Suttlej slopes of Pandrabis between about 9,200 to 11,500 feet to the complete exclusion of the silver fir, the dense oak forest stopping abruptly at the edge of alpine grass-lands. On other exposures in the Pandrabis glens and throughout Taranda this oak occurs as scattered trees or in larger pure groups amongst the open silver fir stands, other trees of the second storey being both species of birch (Betula utilis and alnoides) and the yew. This mixture goes up the hill much higher into the alpine pastures than the pure kharsu does.

On some of the south and south-east aspects of Pandrabis the blue pine runs right up into the kharsu forest, replacing the spruce and silver fir as the high level conifer, but elsewhere the usual sequence is preserved and the spruce rises above either the blue pine or the deodar, which is seldom met with in this belt.

Under/

Under dense pure stands of kharsu oak the shade is so deep that the humus is a deep sour leaf mould with no green plants whatever. The seedlings of the kharsu even cannot persist; the kharsu oak produced a most prolific seed crop in 1927 and the fallen seed was literally germinating in solid heaps, but by the next spring not a seedling had survived in the shade of the oak forest. Many of the stands of this oak are so dense as to give the impression of being a coppice coupe in places where no felling has ever been done, and it would be interesting to know under what circumstances this type of forest has regenerated itself.

Under mixed stands of oak and silver fir the bush growth is not so dense as in the lower spruce forests, but there is a good deal of Arundinaria bamboo and scattered bushes of Acer, Spiraea bella, Pyrus foliolosa, Cotoneaster acuminata, and Rhododendron lepidotum. The herbaceous cover is usually coarse Compositae and Nephrodium fern.

KHARSU/

KHARSU OAK - SILVER FIR VEGETATION LIST.

A. TREES.

Abies Pindrow, Spach.
 " *spectabilis*, Spach.
Acer acuminatum, wall.
 " *pictum*, Thunb.
Betula utilis, D. Don.
 " *alnoides*, Buch-Ham.
Euonymus tingens, Wall.
Picea Smithiana, Boiss.
Pinus excelsa, Wall.
Pyrus foliolosa, Wall.
 " *lanata*, D. Don.
Quercus dilatata, Lindl.
 " *semecarpifolia*, Sm.
Rhododendron lepidotum, Wall.
Taxus baccata, Linn.

B. SHRUBS.

Cotoneaster acuminata, Lindl.
 " *rosea*, Edgew.
Lonicera purpurascens, Walp.
Polygonum polystachyum, Wall.
Rhamnus purpurea, Edgew.
Rubus lasiocarpus, Sm.
Spiraea bella, Sims.
Strobilanthes Dalhousianus, Clarke.
 " *Wallichii*, Nees.
Viburnum nervosum, D. Don.

C. HERBS.

Anaphalis triplinervis, Clarke.
Calamintha Clinopodium, Benth.
Crepis sibirica, Linn.
Erigeron alpinus, Linn.
Fragaria vesca, Linn.
Gaultheria trichophylla, Royle.
Nepeta Govaniana, Benth.
Podophyllum Emodi, Wall.
Primula denticulata, Sm.
 " *petiolaris*, wall.
Saxifraga ligulata, Wall.
Senecio chrysanthemoides, DC.
 " *graciliflorus*, DC.
Spiraea Aruncus, Linn.
 " *vestita*, wall.

D. CLIMBERS/

KHARSU OAK - SILVER FIR VEGETATION LIST.

D. CLIMBERS.

Schizandra grandiflora, Hk.
Vitis semichordata, Wall.

E. GRASSES.

Arundinaria spathiflora, Trin.
Melica scaberrima, Hk.
Pennisetum flaccidum, Grisob.

F. FERNS.

Aspidium Prescottianum, Hk.
Nephrodium barbiggerum, Hk.
" Brunonianum, Hk.
Polypodium amoenum, Wall.

(vii) SERAL COMMUNITIES OF MOIST ZONE.

Each of the foregoing six types of forest is the climax type for the particular conditions in which it is growing, and there is no evidence to show that any of these formations would extend at the expense of the others unless as the result of some considerable change in local climatic conditions.

Within the blue pine-deodar formation, however, a considerable change is in progress, for the pine is a pioneer species on much of the ground for which the deodar is the appropriate climax type. It has been indicated in CHAPTER IV that the blue pine forest has spread over much of the ground which prior to the leasing of the forests was kept as grass-land by constant burning. This colonisation by the blue pine is still in progress wherever it can find an entry on deserted cultivation, or on ground whose surface has been disturbed by rock falls or snow avalanches, at practically any altitude between 5000 and 9000 feet in the moist zone.

The following list gives the species of shrubs and herbs which commonly act as pioneers in occupying freshly broken ground ahead of the blue pine in this area.

SHRUBS/

SHRUBS AND TREES.

Plectranthus rugosus, Wall.
Populus ciliata, Wall.
Rubus biflorus, Buch-Ham.
 " *purpureus*, Bunge.
Spiraea Lindleyana, Wall.
Viburnum cotinifolium, D. Don.

GRASSES.

Agrostis alba, Linn.
Perotis latifolia, Ait.

HERBS.

Anaphalis adnata, DC.
 " *nubigena*, DC.
Arabis alpina, Linn.
Bupleurum falcatum, Linn.
Erysimum hieracifolium, Linn.
Fragaria vesca, Linn.
Impatiens Roylei, Walp.
Lactuca scabrida, DC.
 " *macrorrhiza*, Hk.
Salvia glutinosa, Linn.
Taraxacum officinale, Wigg.
Viola Patrinii, Ging.
Viola serpens, Wall.

CHAPTER VII.

DESCRIPTION OF DRY ZONE AND ARID ZONE
FORMATIONS.

Much of the flora is common to both dry and arid zones, and the two zones are therefore dealt with together in order to prevent the duplication of lengthy vegetation lists.

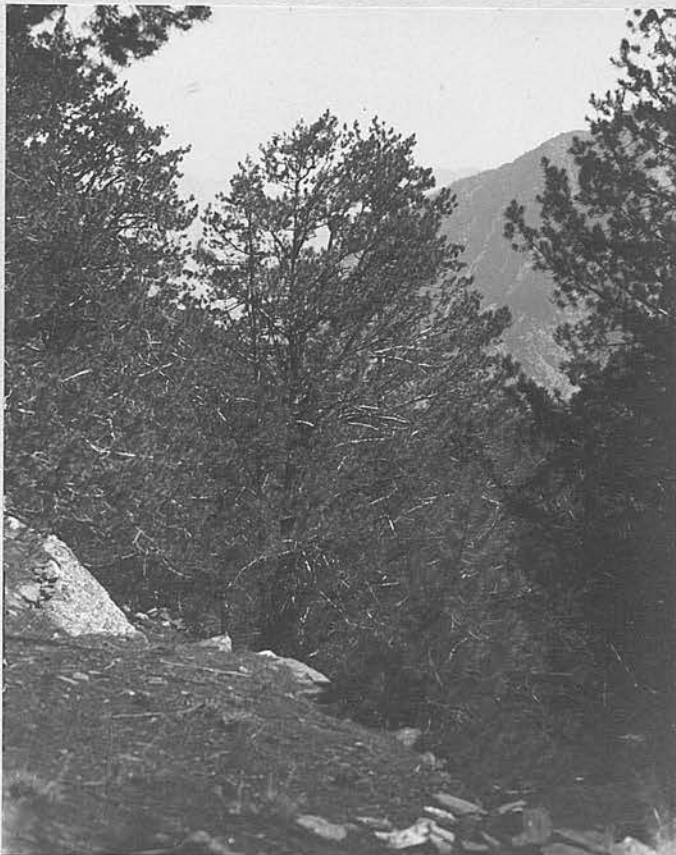
TYPE viii. ILEX OAK - NEOZA PINE FORMATION
OF DRY ZONE.

Quercus Ilex, Linn, the Ilex oak, is a feature of the middle dry zone of the Sotlej from Wangtu up to Purbani and recurring beyond that occasionally as far up as the Tidong junction. It is best developed on the colder south bank and forms pure stands with only an occasional deodar or neoza pine at 6,000 - 8,000 feet from the Mel Gad to Shongtong, including the lower reaches of the Baspa, and fringing the bottom of the deodar belt throughout Kilba Range. It is much less common on the hotter north bank, and forms pure forest in only a few/



FOREST TYPES:- PINUS GERARDIANA.

- (31) Arid zone "protection forests" of deodar and neoza pine
in Ropa Gad (Upper Chini).
- (32) Typical open neoza forest with a scanty soil covering
of Thymus and Roylea.



few places where the aspect is brought round either to east or west on the banks of side-streams, as at Urni and Runang at 8,500 feet and it seldom grows below 7,000 feet on the Chini side.

Pinus Gerardiana, Wall., the neoza pine, is the source of the edible chilgoza nut of the Indian bazaars, and is much more widely met with than the Ilex oak in both dry and arid zones. It replaces the chil pine near Wangtu just where the monsoon becomes ineffective, and continues along the Suttlej lower slopes as far as Kanam, but becoming a dominating feature only beyond the cliffs of the Baspa junction.

In Kilba the neoza dominates the Ilex oak on cliffy ground facing due east downstream, while the oak is the commoner on other aspects where the insolation is less intense. On the Chini side with a southern exposure the lower cliffs have only a scattered crop of stunted neoza from the river level at 5,000 feet up to practically 9,000 feet, though frequently the deodar comes in considerably below that. Similarly in the lower Baspa valley, the Ilex oak is well developed along the colder left bank as a pure forest and also as the dominant member in mixture with the pine and deodar, while on the hotter right bank the lower slopes which are not sheer/

sheer cliff are occupied by scattered neoza and open grass lands, with an inferior type of broad-leaved scrub in the hollows and ravines.

Along the river bottom from Wangtu to the Baspa mouth there is a peculiar type of scrub most of whose members are outer foothill species which have penetrated thus far into the hills along the line of the Suttlej gorge. Such are Olea cuspidata, Zanthoxylum alatum, Sophora mollis, Capparis spinosa and Withania coagulans, and their presence testifies to the extreme summer heat which is generated at the bottom of cliff gorges of the inner hills. Other plants associated with this group and generally outnumbering these foothills immigrants are Quercus Ilex, Fraxinus zanthoxyloides, Plectranthus rugosus and Artemisia maritima. In this zone Artemisia displaces Plectranthus as the dominant bush of the hot valley scrub and Plectranthus is more typical of the Ilex oak and lower deodar forest, in which also Fraxinus is fairly frequent as a small tree.

Another type of broad-leaved scrub is developed along the Baspa valley bottom, mingling with Ilex oak and displacing it from hollows and ravines. The most interesting member of this group is the triangular-leaved Acer pentapomicum, first reported by Dr J.L. Stewart when he was examining the/

the Bashahr forests with Brandis in 1864. Other trees and shrubs of this association are Parrotia, Celtis, Rhus succedanea and punjabensis, Desmodium, Lonicera, Abelia, Buddleia, Villebrunea, and occasionally Bosea Amherstiana.

In the grass-lands of the open neoza forest the coarser Compositae such as Echinops, Cnicus, Picris, Hieracium, Lactuca and Senecio are much in evidence, also Sisymbrium and Pimpinella.

Under a more or less complete canopy of Ilex oak shrub growth is very much reduced, common plants being Salvia glutinosa, Lespedeza, Bupleurum falcatum, Cynanchum Roylei and Verbascum, with occasional bushes of Rosa Webbiana, Caragana brevispina and Abelia.

TYPE XI. NEOZA PINE FORMATION OF ARID ZONE.

Pure neoza forms open forests which cover large areas of the valley beyond Chini and the tree shows its best development in this arid zone. The northward trend of the valley for 8 miles beyond Shongtong causes a sudden increase in aridity and deprives the left bank of its usual northern exposure/

exposure. As a result the Ilex oak takes second place to the neoza and only becomes dominant again when the northern aspect is again resumed in the Purbani forest block. Beyond Purbani, however, the conditions become too arid for the Ilex oak and the neoza occupies both flanks of the valley. It forms an almost unbroken belt of pure forest for 16 miles on the north bank from the mouth of the Kashang Gad to Kanam from about 7,500 feet up to 9,500 feet, with deodar mixed in the upper half. Beyond this the lower slopes of the main Sutlej valley are of bare shale almost devoid of vegetation, but in the Ropa valley to the north there is again an extensive development of neoza mixed with deodar.

These pure stands of neoza are very scattered and the ground flora is also very open. The only other tree is an occasional Fraxinus zanthoxyloides and the usual bushes are Lonicera hypoleuca, Artemisia maritima, Roylea, Astragalus graveolens and Daphne oleoides, and there is a somewhat sketchy ground cover of Thymus and herbs such as Dianthus, Lespedeza, Nepeta supina, and Setaria and Perotis grasses, but as a rule a great deal of the earth surface is quite bare of either plant life or vegetable mould, rendering this type of country/



ARID ZONE FORESTS.

- (33) Suttlej valley near the Tidong junction; pure neoza belt on left; deodar and blue pine on right.
- (34) Teti Gad in Upper Chini; neoza below, deodar on nearer ground, and high-level blue pine round head of valley.



country peculiarly liable to erosion by heavy rainstorms. Beyond Jangi, the cushion-scrub of the arid alpine zone comes down towards the river bed, Cotoneaster microphylla and Juniperus communis being fairly common, while Ephedra begins to displace Art^emisia as the commonest shrub in and beyond Ropa Gad.

VEGETATION/

VEGETATION LIST for DRYZONE ILEX-OAK - NEOZA PINE
and ARID ZONE NEOZA PINE FORMATIONS.

A. TREES.

(a) Common to both zones.

Acer pentapomicum, Stew.
Celtis australis, Linn.
Fraxinus zanthoxyloides, Wall.
Parrotia Jacquemontiana, Decne.
Pinus Gerardiana, Wall.
Pistacia integerrima, Stew.
Quercus Ilex, Linn.
Rhus punjabensis, Stew.
 " *succedanea*, Linn.

(b) Confined to dry zone.

Olea cuspidata, Wall.
Zanthozylum alatum, Roxb.

(c) Confined to arid zone.

Prunus Jacquemontii, Hk.
 " *prostrata*, Labill.

B. SHRUBS.

(a) Common to both zones.

1. *Abelia triflora*, R.Br.
Artemisia maritima, Linn.
 " *vulgaris*, Linn.
Astragalus anomalus, Bunge.
 " *tibetanus*, Benth.
Berberis Edgeworthiana, C.K. Schn.
 " *Jaeschkeana*, C.K. Schn.
Capparis spinosa, Linn.
Caragana brevispina, Benth.
Daphne oleoides, Schreb.
Desmodium nutans, Wall.
Indigofera Dosua, Buch-Ham.
Lonicera hypoleuca, Decne.
Microglossa albescens Clarke.
Plectranthus rugosus, Wall.
Rosa Webbiana, Wall.
Roylea calycina, Briquet.
Thymus Serpyllum, Linn.

(b)/

(b) Confined to dry zone.

Bosea Amherstiana, Hk.
Buddleia paniculata, Wall.
Elaeagnus umbellata, Thunb.
Lonicera angustifolia, Wall.
 " *quinquelocularis*, Hardw.
Scutellaria repens, Buch-Ham.
Sophora mollis, Grah.
Villebrunea frutescens, Blume.
Withania coagulans, Dun.

(c) Confined to arid zone.

Astragalus cicerifolius, Royle.
 " *polyacanthus*, Royle.
 " *graveolens*, Buch-Ham.
 " *leptocentrus*, Bunge.
Colutea nepalensis, Sims.
Cotoneaster microphylla, Wall.
Caragana Gerardiana, Benth.
Ephedra Gerardiana, Wall.
 " *intermedia*, Schrenk.
Lactuca orientalis, Boiss.
Potentilla rigida, Wall.
 " *Salesoviana*, Steph.

C. HERBS.(a) Common to both zones.

Aster molliusculus, Wall.
Bupleurum falcatum, Linn.
Cynanchum Roylei, Wight.
Cynoglossum micranthum, Desf.
Dianthus angulatus, Royle.
Hyssopus officinalis, Gay.
Impatiens brachycentra, Kar.
Lespedeza dubia, Schindler.
 " *floribunda*, Bunge.
Nepeta discolor, Royle
Phlomis spectabilis, Falc.
Pimpinella diversifolia, DC.
Rumex hastatus, D. Don.
Salvia glutinosa, Linn.
Senecio chrysanthemoides, DC.
Silene Griffithii, Boiss.
Sisymbrium Alliaria, Scop.
 " *strictum*, Hk.
Tylophora Govanii, Decne.
Taraxacum Officinale, Wigg.
Verbascum Thapsus, Linn.
Veronica Beccabunga, Linn.

(b) Confined to dry zone.

Amphicome arguta, Royle.
Onicus Wallichii, Hk.
Echinops niveus, Wall.
Hieracium vulgatum, Fries.
Lactuca longifolia, DC.
Origanum vulgare, Linn.
Phagnalon niveum, Edgew.
Picris hieracioides, Linn.
Saussurea candidans, Clarke.
Stachys melissaefolia, Benth.
Veronica biloba, Linn.

(c) Confined to arid zone.

Nepeta supina, Stev.
Silene kunawarensis, Royle.
Hyoscyamus niger, Linn.

D. GRASSES.(a) Common to both zones.

Agropyron longearistatum, Boiss.
Agrostis alba, Linn.
Eragrostis nigra, Nees.
Perotis latifolia, Ait.
Phleum arenarium, Linn.
Setaria viridis, Beauv.

(b) Confined to dry zone.

Andropogon Gryllus, Linn.
Apluda aristata, Hack.
Arthraxon submuticus, Hochst.
Lolium temulentum, Linn.
Pollinia quadrinervis, Hack.

E. FERNS.(a) Common to both zones.

Asplenium Ceterach, Linn.

(b) Confined to arid zone.

Gymnogramme aurita, Hk.

T Y P E IX.

D R Y Z O N E D E O D A R.

South of the Sutlej the deodar belt is continuous throughout the whole of the dry zone and covers enormous areas of ground between 7,000 and 10,000 feet. This belt at one time contained some of the finest deodar in the whole of the Himalayas, but many of these primeval forests have now been replaced by young pole crops. North of the river there is a large area of deodar in the Bhabba valley, but on the main valley slopes the deodar belt is not by any means continuous, and forest is frequently displaced by screes and bare cliffs.

(a) NICHAR-JANI DEODAR GROUP.

From Nichar to the Dulang Gad on the south bank the deodar is well developed on the shoulders of the spurs, which rise between the various side-streams, thus forming large blocks of pure forest near the main river around Nichar, Panwi, Dippi and Jani. In such places there is usually a lower fringe of blue pine or scattered chil pine below 7,000 feet near Nichar, and the Quercus Ilex and neoza pine come in to replace it in the east. The blue pine also occurs as an occasional tree amongst the deodar throughout the forest. At 9,000 feet the blue pine and/

and spruce both filter in and eventually displace the deodar altogether above 9,500 feet, confining it more and more strictly to the ridges with increase in altitude.

In the interior of each side-valley the deodar persists on rocky spurs and forms a considerable percentage of the forest, but much of the ground is so precipitous as to be quite inaccessible - e.g. Deskudang Compartment 7. Elsewhere in these valleys the slopes are occupied by spruce and blue pine and the ravine bottoms by a broad-leaved mixture, though scattered deodars are found much more frequently here than in similar damp forest types further west in Taranda.

Under pure or nearly pure deodar the common shrubs are Plectranthus, Indigofera Gerardiana, Coton-easter bacillaris, Rubus niveus and Berberis aristata, with some Adiantum fern, Geranium, Valeriana, Fragaria and Viola, while under dense pole crops Smilax and Gerbera lanuginosa are the common herbs. Where blue pine is dominant Desmodium tiliaefolium, Asparagus filicinus, Salvia glutinosa, Nephrodium barbig-erum and bracken are more in evidence, and where spruce also occurs in the mixture Ainsliaea, Polygonum, and Pteris cretica as a ground cover and Viburnum cotinifolium as a shrub are common. In the ravines/

ravines the common trees are Rhus succedanea, walnut and poplar, and the bushes are Staphylea Emodi, Cara-gana brevispina and Berberis Lycium.

Features of this group are the absence of any oak at the level of the deodar belt except for a little moru oak at Panwi, and also the way in which the deodar forest frequently abuts upon open grass-land along its lower fringe. This group also marks the final elimination of spruce as the dominant species of the middle forest belt.

(b) KILBA-BRUA DEODAR GROUP.

This group comprises the Lishnam forests in the Dulang Gad, then an unbroken stretch of deodar in the Kilba forests, continued in the lower Baspa up to Shoang. In this area Quercus Ilex forms the main species where the deodar comes in first at 7,000 feet and continues in mixture with the deodar up to 8,000 feet. The deodar between 7000 and 7500 is distinctly poor with a very conical bole, poor height growth and becoming stagheaded at an early age. Above this it improves rapidly and the top part of the Ilex-deodar mixture produces some fine timber. On some of the hotter aspects the lower deodar is mixed with neoza, instead of oak - e.g. the eastward aspects of the Teuden and Kanai spurs above the Baspa-Sutlej junction.

The/

The main belt of pure deodar extends upwards to 9500 feet, but occasional trees are found as high as 10500 feet. The upper forest consists largely of blue pine, while the spruce is confined to the subalpine belt in mixture with silver fir and birch. Ilex oak is dominant throughout most of the reentrants and a special ravine flora is only found in restricted areas, into which the deodar usually penetrates. The deodar-Ilex oak formation has usually a scattered bush growth of Lonicera quinquelocularis and angustifolia, Fraxinus zanthoxyloides, Daphne oleoides, Plectranthus, and Artemisia vulgaris, with Rosa moschata as a creeper over trees and Cynanchum Roylei trailing on the ground. There is often a crop of herbaceous weeds such as Cannabis sativa and Corydalis sown by the grazing and browsing animals, because these Ilex oak woods form the main winter grazing grounds. In some places owing to the excessively heavy grazing Salvia glutinosa is the only ground cover left, as even goats will not touch it.

Where neoza runs up into the deodar on the Kanai cliffs the forest is open and on all ledges there is a fairly heavy scrub growth of poplar, Parrotia, Acer pentapomicum, Spiraea, Abelia, and Rubus, with a rough herbage of Erysimum, Bupleurum, Stellaria and Cynanchum, while on sheet rock Plectranthus/

Plectranthus is the sole survivor. In pure deodar stands of good growth there is a fairly regular shrub growth of Indigofera, Desmodium, Artemisia vestita, Jasminum, and Abelia, with a certain amount of bracken and Adiantum fern, and a herb growth of Thalictrum, Valeriana Wallichii, Nepeta, Anaphalis nubigena and triplinervis, Geranium, Fragaria and Elscholtzia cristata.

In the drier type of deodar on stony ridges which shows a poor height growth, the shrubs are Plectranthus, Microglossa, Artemisia vulgaris, Berberis, Anaphalis Royleana, Desmodium, and Viburnum with very few herbs except Salvia glutinosa and a few Compositae.

In the damper stands on ravine slopes the deodar develops well, some of the trees of this type in Lishnam being very fine indeed. Here there is a heavy shrub growth of Rhus succedanea and punjabe-
sis, Cedrela serrata, Acer pentapomicum, Rhamnus virgata, Deutzia corymbosa, Spiraea Lindleyana, Desmodium and Polygonum polystachyum which crowds out any herbaceous ground flora.

In the damper stands away from the ravines and towards the upper part of the deodar belt where blue pine and an occasional spruce appear, bracken fern and Ainsliaea aptera are common under close canopy/

canopy, while more open places have a bush growth of Berberis and Cotoneaster, and Dioscorea and Clematis are common as climbers.

(c) UPPER BASPA DEODAR GROUP.

With the valley bottom at 8000 feet the deodar comes right down to the river bed and except in very damp ravines persists up to practically 10,000 feet, being mixed above 9500 feet with blue pine on the ridges and spruce and silver fir elsewhere.

Many of the riverside stands are on the coarse shingle beds of the old raised beaches, which are exceedingly dry and the deodar growth is slow and poor. Along the water's edge there is Hippophae, Myricaria, and Impatiens, while along with the deodar on the raised beds there are Astragalus tibetanus and anomalus, and Compositae such as Lactuca longifolia, Prenanthes Brunoniana, Echinops, Cnicus and Tragopogon.

In this group there is a curious recrudescence of the low level blue pine, which comes in below the deodar around the Raturang Falls from 7500 to 8500 feet. The appearance of the blue pine at this level and a recurrence of spruce in preference to blue pine at 10,000 feet both indicate an/



FOREST TYPES:- BASPA VALLEY FORESTS.

- (35) Dry type of silver fir and Rhododendron lepidotum at 10,000 to 11,000 feet.
 (36) Quercus Ilex and deodar in Brua Gad, a side-stream of the Baspa.



an improvement on the climate of the main Suttlej valley, but unfortunately there are no statistics of the Baspa valley rainfall.

The associates of this lower pine are commonly Salvia glutinosa, Plectranthus, Pimpinella, Wikstroemia and occasionally Acer pentapomicum and Parrotia. Peculiar features here are dense gregarious masses of the fern Osmunda Claytoniana and Mentha sylvestris each covering large blanks in the pine canopy.

The lower deodar forest contains a dense growth of Plectranthus and Salvia glutinosa which together form a serious handicap for deodar regeneration. Above this, common plants under open deodar are Astragalus chlorostachys, Nepeta spicata, Cranio-tome versicolor, and Prunella vulgaris with the usual shrubs, while under a close canopy Indigofera bushes are well grown and Thalictrum is the only common herb.

(d) WADANG DEODAR GROUP.

This presents an intensely arid type of forest on the precipitous south-east aspect of the Kanawar Kailas peaks. The lower fringe of this forest is said to have been worked out by early traders and is now open grassland, while the upper part escaped owing to its inaccessibility. It contains/

contains a scattered crop of magnificent old trees, many of them dry topped, and almost all with their bases on the uphill side smashed by falling rocks.

Neozsa and a few deodar come in at 7600 feet and deodar continues up to 9700 feet, above which blue pine and silver fir come in. The ground flora associated with deodar is of well developed shrubs such as Abelia, Indigofera Gerardiana and I. Dosua, Rhamnus virgata, Lonicera angustifolia, a Desmodium much nearer nutans than tiliaefolium and an irregular ground covering of Clematis montana and Thymus.

(e) RALLI-BARANG DEODAR GROUP.

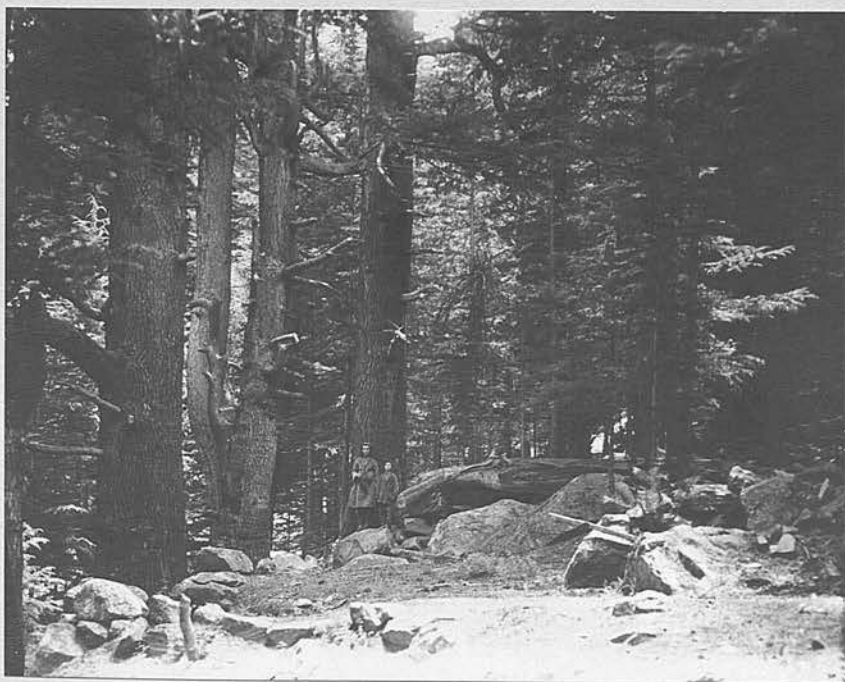
In this belt along the Suttlej south bank the deodar comes in at 7500 or a little above this as scattered trees amongst neozsa and Ilex oak, but does not form pure forest until over 8000 feet. Occasional blue pine come in above 9300 feet, and towards 10,000 feet blue pine and spruce predominate, the deodar disappearing at about 10,300 feet.

Quercus Ilex is accompanied by an inferior type of deodar amongst Lonicera and Abelia bushes, as in the Kilba group, but above 8500 feet this area contains splendid forest, much of which has now been worked out and replaced by very fine young deodar crops, in fact Ralli forest contains the best deodar regeneration area in the whole of Bashahr. In this forest/



DRY ZONE DEODAR.

- (37) Deodar forest on Rogi cliffs; on the right, Barang forest belt on the flanks of Kailas.
- (38) Purbani forest; old deodars preserved as part of a temple grove with sapling crops all around them.



forest grass growth is fairly dense but is not heavy enough to stop seedlings even in open places. Both Indigofera Gerardiana and Desmodium tiliaefolium show growth of 14 to 18 feet in height, but there is very little herbaceous growth except occasional Fragaria and Asparagus gracilis.

In the other forests of this group the regeneration is good but not so prolific as in Ralli. In them Thymus, Microglossa albescens, and Anaphalis Royleana are common under deodar, denoting a distinct advance in aridity for these northern aspects. Other plants common lower down the valley continue:- viz:- Lonicera, Abelia, Indigofera, Salvia glutinosa and Artemisia vestita, but Desmodium is now less in evidence under deodar canopies. In areas where regeneration has prospered, the common herbs are Thalictrum, Fragaria, Astragalus Candolleanus and A. rhizanthus, and the three Polygonatums (multiflorum, verticillatum and cirrhiifolium). In areas unduly exposed by over-felling or rendered sterile by excessive debris-burning there are Verbascum, Chenopodium opulifolium, Impatiens brachycentra, and Leptorhabdos Benthamiana, all plants of ill-omen for deodar because regeneration seldom prospers along with them.

In the upper part of the deodar belt where there/

there is an appreciable mixture of blue pine and spruce there is a well developed herbaceous ground cover of the "leguminous turf" so typical of the dividing line between the deodar and the high level blue pine and consisting of Astragalus spp, Oxytropis mollis, Thymus, Lespedeza floribunda and Lotus corniculatus.

In the ravines common bushes are Salix denticulata and Euonymus lacerus, in addition to the usual Spiraea and Viburnum.

(f) BHABBA VALLEY DEODAR GROUP.

The main deodar-bearing areas of the Bhabba are where the stream runs south-west hence the two banks have south-east and north-west exposures and very different types of forest. The colder N.-W. aspect (Rushnang) carries deodar from 6000 feet up to 9500 feet while the opposite S.-E. aspect (Yeti) has deodar from 8500 to 11,000 feet. Both sides are precipitous and contain large stretches of naked cliff, but are nevertheless valuable forests which are now being thoroughly worked for the first time.

In Rushnang there is an open crop of very fine old deodar from the valley bottom up 9,000 feet, above which spruce comes in and replaces the deodar entirely at 9,500 feet, except for occasional trees on/

on rocky spurs. Exposed cliffs carry Plectranthus, Artemisia, and Desmodium nutans, while good average deodar ground has a heavy shrub growth of Abelia, Rhamnus virgata, Berberis pseudumbellata, Jasminum, and Rosa sericea, with bracken in gregarious patches. There is a considerable development of broad-leaved scrub in all the smaller reentrants, consisting of Aesculus, Rhus succedanea, and masses of Strobilanthes alatus ten feet high. Where the spruce mixture comes in there is the usual herbaceous cover of Astragalus chlorostachys, Thalictrum neurocarpum, Ainsliaea, Bupleurum Candollii and Adiantum fern.

In Yeti on the opposite side, scattered deodar and blue pine do not appear in the hot grasslands until between 8,000 and 8,500 feet amongst herb species such as Androsace, Anaphalis, and Lespodoza, typical of the chil pine belt. Species of this belt also continue up to 9,500 feet amongst very scattered and stunted deodar, viz. Rhus Cotinus, Rumex hastatus, Stachys sericea and Salvia lanata.

From 9500 to 10500 the deodar is well developed as an open forest on all ridges and ledges capable of retaining soil, with shrubs such as Rosa sericea, Caragana brevispina, bracken and Salvia glutinosa in the open, and a herb growth of Thalictrum, Nepeta, Roscoeia, and Thermopsis. The reentrants/

reentrants are generally bare stone/chutos, dangerous from constantly falling rocks, or where vegetation persists there is a dense mass of Polygonum polystachyum and Impatiens scabrida and I. Roylei up to 8 feet high.

(g) URNI-ROGI DEODAR GROUP.

This contains only one forest of commercial value, and it occurs where the Runang Gad provides a western exposure. Here, there is some very fine deodar but regeneration is being interfered with by a very heavy weed growth of Rubus, Microglossa, Asparagus, Berberis and a mass of herbs such as Impatiens, Chaerophyllum, Thermopsis, Potentilla, Anemone, Anaphalis, and bracken fern.

In the dry park-like open stands of deodar on the arid southern exposure above the Rogi cliffs, there is a scattered shrub growth of Artemisia maritima and vulgaris, amongst a turf of Dianthus angulatus and Thymus, with occasional herbs such as Erysimum hieracifolium, Pimpinella, Senecio and Leptorhabdos.

Between Rogi and Chini there are three small regeneration areas where eastern aspects are provided and the type of deodar improves. The flora in these places is somewhat similar to the deodar areas of the Upper Baspa which have already been discussed.

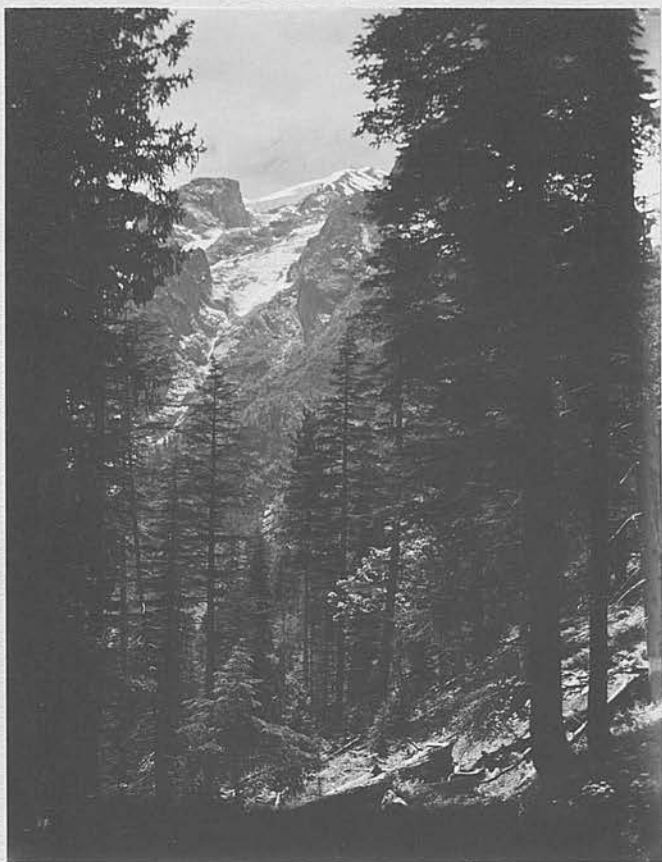
T Y P E X I I .

A R I D Z O N E D E O D A R .

(a) CHINI-POARI DEODAR GROUP.

The northward trend of the river between Chini and Purbani leads to a more equal development of the forest on both banks, and there is also a marked increase in aridity. The neoza pine occupies most of the south slopes up to 10,000 feet as pure forest, and on other colder exposures it continues as a mixture in deodar up to quite 9,500 feet. The deodar throughout is of much poorer height growth than the average dry zone type and is confined to the colder aspects. The typical crop of this group is in strips running up the more sheltered side of each spur, with neoza predominating on the hotter side and the intervening hollows blank from the constant abrasion of snow slides, or carrying at best a few dwarf deodar deformed and degraded to a misshapen bush.

The deodar regeneration even on sheltered aspects tends to keep to the skirts of old trees whose shade gives protection from the hottest sun while on more insolated slopes the deodar comes in best with the help of a fairly dense neoza crop acting as nurse, and seldom establishes itself in the open./



DRY ZONE DEODAR REGENERATION.

- (39) "Seeding felling" in Barang forest; heavy opening up has not been followed by regeneration except in side-shade of standards.
- (40) Delay in making final felling in Rogi forest has checked back the young crop in the shade of the old tree.



open.

The dry deodar-neoza crops have a scattered bush growth of Artemisia maritima, Lonicera hypoleuca, and a sketchy ground cover of Thymus, Polygonum paronychioides, and Dianthus, with occasional Astragalus graveolens, Verbascum and Silene Griffithii. More regular deodar crops contain a heavier but still scattered shrub growth of Desmodium, Microglossa, Anaphalis Royleana, Ribes Grossularia, Rubus purpureus and Wikstroemia canescens with a herb growth of Artemisia vestita, Veronica Beccabunga, very much reduced Thalictrum minus, Impatiens brachycentra, Carum Carvi, Craniotome versicolor, Anthriscus nemorosa, Nepeta discolor and supina, and Senecio pedunculatus.

Towards the top of the deodar belt where blue pine and firs come in, the shrubs are still much the same species as lower down, but under the blue pine the usual leguminous turf comes in, while under silver fir and blue pine on the damper slopes the herbs are Halenia elliptica, Bupleurum tenue, Nepeta Clarkei, Veronica, Phlomis bracteosa, Erigeron alpinus and Anaphalis cinnamomea.

(b) PURBANI - PANGI - KASHANG DEODAR GROUP.

This comprises three good blocks of deodar forest which have developed, in spite of the increased aridity of the valley, on the northern exposures provided/

provided by the Purbani slopes of the main river and by the valleys of the Malun and Kashang Gads running north-west up into the Spiti hills. On the hotter aspects the deodar is largely mixed with neoza and is of the type already discussed above under (a), but there are considerable areas of valuable deodar showing very good height growth and reaching a large size. These latter depend largely for their moisture upon the remains of winter snow-beds lasting on these colder northern slopes until late in the spring, for the summer rain-fall here does not exceed 7 inches for the 7 months May to November.

In the two side-valleys the deodar comes in rather lower than it does in the main valley, and the reentrant flora is much more luxuriant and varied, but the general type is similar. The drier slopes have a fairly regular bush growth of Abelia, Lonicera hypoleuca and quinquelocularis, Artemisia vulgaris and vestita, Ribes, Rosa, Rubus and Plectranthus, and less commonly Jasminum, Asparagus gracilis, bracken and Asplenium Trichomanes fern. At higher levels these dry slopes also carry Cotoneaster microphylla, Verbascum, Leptorhabdos and varieties of the leguminous turf containing a lot of Thymus and Leontopodium. Cooler aspects with proportionately better deodar with/

with a more regular canopy carry a shrub growth of Indigofera, Desmodium, Cotoneaster obovata and Berberis Edgeworthiana, with a well developed herb growth of Thalictrum, Adiantum, Fragaria and Polygonatum, with Nephrodium sparsum and Gymnogramme aurita as occasional ferns.

The sloping hollows and reentrants which carry the finest deodar in Pangi and Kashang have a dense growth of shrubs and tall herbs and creepers forming a mass of vegetation, but in such situations the young deodar is quite capable of penetrating through this. It contains Salix daphnoides, Philadelphus tomentosus, Jasminum, Rubus, Rosa, Salvia glutinosa, Bupleurum Candollii, Astragalus chlorostachys, Thalictrum reniforme, Lilium polyphyllum and Polygonatum multiflorum with Rubia, Galium, and Dioscorea as climbers.

The ravine bottoms are often bare stone chutes, but they generally contain Acer caesium and acuminatum, Viburnum, Spiraea, Syringa Emodi, and Euonymus lacerus. In such places the spruce comes in above the deodar, but elsewhere the blue pine is much more in evidence. Between 9,500 and 10,000 feet on most aspects the deodar is mixed with a good deal of blue pine and the ground flora consists of leguminous/

leguminous turf in most places, giving way to an arid scrub of Juniperus communis and Ribes Grossularia on the hotter slopes.

(c) RIBBA - TIDONG DEODAR GROUP.

This contains a 12-mile belt of deodar forest on the south bank of the Sutlej continued into the Tidong valley, and well developed wherever sufficient soil and a northern aspect can be found. The conditions are extremely arid and the deodar must depend almost entirely upon winter snow for its moisture. It occurs scattered with neoza at about 8,000 feet near the Sutlej river bank, but is here very stunted and conical.

It is not until about 8,800 feet that it develops good height growth and then only on the more sheltered slopes. Much of the best forest has been mutilated by heavy lopping to provide long poles for the local vineyards, and trees have an enormous stumpy bole bearing a mass of upright poles as branches.

Under a dense deodar canopy there is absolutely no ground flora whatever and seedling regeneration dies off very quickly under heavy shade, the loss of dew under the heavy crowns probably being the reason for this. Under neoza and deodar there is/

is a scattered shrub growth of Lonicera hypoleuca, Ephedra, Roylea, Artemisia maritima, Daphne oleoides, Caragana Gerardiana, Berberis Edgeworthiana and Jaeschkeana, and Polygonum paronychioides, while the herbaceous growth is even more scattered, consisting of Rubia, Nepeta discolor and ^{and} supina, Senecio, with an occasional Fraxinus zanthoxyloides tree. The bulk of the ground, however, is bare rock and scree.

Under the better class of pure deodar between 9000 and 9500 feet Abelia is found as a bush of 12-14 feet in height, other bushes being Berberis and Ribes Grossularia and orientale, with some Thalictrum minus wherever soil and shade are provided, also Rheum, Thymus, Arenaria foliosa and festucoides, and Asplenium fontanum scattered amongst the rocks. Where the blue pine comes in above this, the usual leguminous turf is very strongly developed in these arid forests, containing a varying percentage of Astragalus rhizanthus, A. pedunculatus and A. strobiliferus, Oxytropis mollis, Polygonum paronychioides, Nepeta supina, Hyssopus officinalis, Cicer soongaricum and Fragaria vesca.

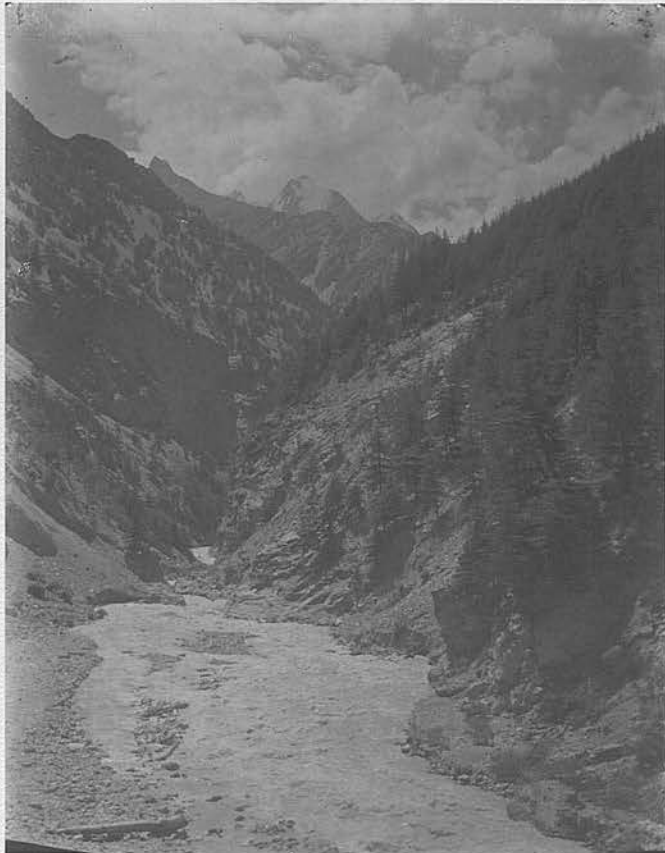
(d) UPPER CHINI GROUP.

This comprises the balance of the forests in/



ARID ZONE FORESTS.

- (41) Open forest of deodar, neoza pine, and blue pine at
Labrang, 8,000-10,000 feet.
- (42) Teti Gad valley bottom at 9,200 feet; deodar on right (the
cooler aspect) and neoza on left (the hotter aspect).



in the upper valley of the Sullej and in the Teti^a and Ropa Gads. There is ^Δconsiderable area of scattered and rather poor deodar forest which is of great local value in providing building timber for the inhabitants, but forest of commercial value for export purposes is confined to the Teti Gad.

The deodar is closely confined to the most sheltered northern aspects, and only appears on southern faces as a mixture in well established neoza forests such as the Rarang-Jangi belt. It is seldom found much below 9,500 feet and usually stops above at about 10,500 feet. In this zone the moisture requirements of the deodar approximate closely to those of the high level blue pine, and the ground flora of the two, even when they occur separately, is very similar.

The usual scattered and very stunted type of deodar in this excessively arid area is accompanied by a very irregular and open shrub growth of Artemisia maritima, Ephedra intermedia and Gerardiana, Caragana versicolor and Gerardiana, Capparis spinosa, Colutea nepalensis and an occasional Fraxinus tree.

A better class of deodar, though still very stunted, is found higher up on hillsides of bare loose quartzite blocks in Teti Gad, and this has Ribes orientale and Rosa Webbiana both growing into shrubs/

shrubs of 12 feet in height, cushion-scrub of Juniperus communis and pseudosabina, and Juniperus macro-poda forming poles of 16-20 feet growing out of the centre of a clump of its own shrub growth, in the same manner as the spruce of the prés boisés of the Swiss Alps. Artemisia maritima is ubiquitous, while A. vulgaris and Salvia glutinosa are here restricted to the better class of open deodar forest. The scree Astragalus species, namely A. tibetanus, A. anomalus and A. cicerifolius, are fairly common, also Lonicera hypoleuca, Roylea, Prunus Jacquemontii, and a very open form of turf containing Thymus, Polygonum, Nepeta, Lactuca orientalis, Dianthus, and Hyssopus, covering rock screes. Where surface soil exists there are Tanacetum senecionis, Adonis scrobiculata, Medicago falcata, all characteristic as field weeds and probably brought in by grazing animals; also Cynoglossum and Myosotis which are usually associated with the high level blue pine. The barriers of the altitudinal zones so strictly observed by plant life in the outer hills tend to break down in this arid country and all the surviving plants congregate on the most sheltered sites irrespective of their previous habitat.

Owing to the large number of plants common to both dry and arid zones, the vegetation lists for/



DEODAR FOREST TYPES.

- (43) Deodar in upper Baspa growing on alluvial shingle beds along river's edge at 8,300 feet.
- (44) Arid zone deodar at Purbani provides protection for village and cultivation at 9,700 feet.



for the two zones have been combined. In order to show the ecological value of the deodar associates they have been grouped under four heads, namely:-

1. Plants belonging to ravine associations.
2. Plants denoting moist conditions for deodar.
3. Plants denoting good conditions for deodar.
4. Plants denoting dry conditions for deodar.

VEGETATION LIST FOR DRY ZONE AND ARID
ZONE DEODAR.

1. RAVINE ASSOCIATIONS.

A. Trees and Shrubs:-

(a) Common to both dry and arid zones.

Acer acuminatum, Wall.
" *caesium*, Wall.
Alnus nitida, Endl.
Celtis australis, Linn.
Deutzia corymbosa, R.Br.
Euonymus lacerus, Buch - Ham.
Hippophae salicifolia, D.Don.
" " *rhamnoides*, Linn.
Myricaria elegans, Royle.
" " *germanica*, Desv.
Parrotia Jacquemontiana, Decne.
Populus ciliata, Wall.
Quercus Ilex, Linn.
Rhus punjabensis, Stew.
" *succedanea*, Linn.
Salix daphnoides, Vill.
" *denticulata*, Anders.
" *viminialis*, Linn.
Spiraea Lindleyana, Wall.
Staphylea Emodi, Wall.
Syringa Emodi, Wall.
Viburnum cotinifolium, D.Don.

(b) Confined to dry zone.

Berchemia lineata, DC.
Cedrela serrata, Royle.
Corylus Colurna, Linn.
Polygonum amplexicaule, D.Don.
" *polystachyum*, Wall.
Spiraea canescens, D.Don.

(c)/

(c) Confined to arid zone.

Astragalus coluteocarpus, Boiss.

B. Herbs.

(Common to both dry and arid zones)

Androsace sarmentosa, Wall.
 Aquilegia pubiflora, Wall.
 Heracleum candidans, Wall.
 " canescens, Lindl.
 Impatiens amplexicaulis, Edgew.
 " gigantea, Edgew.
 " scabrida, DC.
 Polygonum chinense, Linn.
 Salvia glutinosa, Linn.
 Sedum Ewersii, Ledeb.
 Sempervivum acuminatum, Jacquem.
 Valeriana Hardwickii, Wall.

2. PLANTS DENOTING MOIST CONDITIONS FOR DEODAR.

(Seldom found in arid zone except near water channels)

A. Herbs.

Anemone rivularis, Buch - Ham.
 Angelica glauca, Edgew.
 Coriandrum sativum, Linn.
 Geranium nepalense, Sweet.
 Polygonum alatum, Buch - Ham.
 Potentilla argrophylla, Wall.
 " nepalensis, Hk.
 Stellaria crispata, Wall.
 Thalictrum reniforme, Royle.
 Urtica dioica, Linn.

B. Ferns.

Adiantum Capillus-Veneris, Linn
 " venustum, Don.
 Dicksonia appendiculata, Wall.
 Nephrodium sparsum, Don.
 Polypodium lineare, Thunb.
 Pteris pellucida, Presl.

3. PLANTS DENOTING GOOD CONDITIONS FOR DEODAR.

A. Trees and Shrubs.

(Common to both dry and arid zones.)

Abelia triflora, R.Br.
Abies Pindrow, Spach.
Artemisia vestita, Wall.
Astragalus chlorostachys, Lindl.
Berberis aristata, DC.
 " *pseudumbellata*, Parker.
Caragana brevispina, Benth.
Cotoneaster bacillaris, Wall.
 " *obovata*, Wall.
Desmodium tiliaefolium, G.Don.
Indigofera Gerardiana, Wall.
Jasminum humile, Linn.
 " *officinale*, Linn.
Lonicera angustifolia, Wall.
 " *quinquelocularis*, Hardw.
Philadelphus tomentosus, Wall.
Picea Smithiana, Boiss.
Pinus excelsa, Wall.
Prunus persica, Stokes.
Rhamnus virgata, Roxb.
Rosa sericea, Lindl.
Rubus biflorus, Buch - Ham.
 " *niveus*, Wall.
Salix daphnoides, Vill.
 " *Wallichiana*, Anders.

B. Herbs.

Amaranthus paniculatus, Linn.
Anaphalis nubigena, DC.
Anaphalis triplinervis, Clarke.
Asparagus gracilis, Royle.
Atropa Belladonna, Linn.
Bupleurum Candollei, Wall.
 " *lanceolatum*, Wall.
Chaerophyllum villosum, Wall.
Craniotome versicolor, Reichb.
Cynanchum auriculatum, Royle.
 " *Dalhousiae*, Wight.
Elscholtzia cristata, Willd.
Fragaria vesca, Linn.
Lilium polyphyllum, D.Don.
Mentha sylvestris, Linn.
Nepeta/

B. Herbs. contd.

Nepeta leucophylla, Benth.
Nepeta spicata, Benth.
Polygonatum cirrhifolium, Royle.
 " *multiflorum*, All.
 " *verticillatum*, All.
Polygonum affine, D. Don.
Polygonum molle, D. Don.
Prenanthes Brunoniana, Wall.
Prunella vulgaris, Linn.
Pterotheca Falconeri, Hk.
Roscoeia spicata, Sm.
Thalictrum foliolosum, DC.
 " *javanicum*, Blume.
 " *minus*, Linn.
Viola Patrinii, Ging.
 " *Serpens*, Wall.

C. Climbers.

Dioscorea deltoidea, Wall.
 " *melanophyma*, Prain.
Polygonum pterocarpum, Wall.

D. Ferns.

Asplenium Ceterach, Linn.
Cystopteris fragilis, Bornh.
Gymnogramme aurita, Hk.
Polypodium Dryopteris, Linn.
 " *subdigitatum*, Blume.

E. Grasses.

Andropogon tristis, Nees.
Calamagrostis litterea, DC.
Festuca Myuros, Linn.
Poa pratensis, Linn.

4. PLANTS DENOTING DRY CONDITIONS FOR DEODAR.

A. Trees and Shrubs.(a) Common to both dry and arid zones.

Anaphalis Royleana, DC.
Artemisia maritima, Linn.
 " *vulgaris*, Linn.
Berberis/

Berberis Edgeworthiana, C.K.Schn.
Clematis montana, Buch - Ham.
Cotoneaster microphylla, Wall.
Daphne oleoides, Schreb.
Desmodium nutans, Wall.
Indigofera Dosua, Buch - Ham.
 " *Gerardiana*, var.
 heterantha, Wall.
Microglossa albescens, Clarke.
Pinus Gerardiana, Wall.
Plectranthus rugosus, Wall.
Prunus Jacquemontii, Hk.
Prunus prostrata, Labill.
Quercus Ilex, Linn.
Rosa Webbiana, Wall.
Roylea calycina, Briquet.
Rubus purpureus, Bunge.
Thymus Serpyllum, Linn.
Wikstroemia canescens, Meissn.

(b) Confined to arid zone deodar.

Berberis Jaeschkeana, C.K.Schn.
Capparis spinosa, Linn.
Caragana Gerardiana, Benth.
 " *versicolor*, Benth.
Colutea nepalensis, Sims.
Ephedra Gerardiana, Wall.
 " *intermedia*, Schrenk.
Fraxinus zanthoxyloides, Wall.
Juniperus communis, Linn.
 " *macropoda*, Boiss.
 " *pseudosabina*, Fisch.
Lonicera hypoleuca, Decne.
Ribes Grossularia, Linn.
 " *orientale*, Desf.

B. Herbs.

(a) Common to both dry and arid zone deodar.

Anthriscus nemorosa, Spreng.
Aster altaicus, Willd.
 " *molliusculus*, Wall.
Bupleurum falcatum, Linn.
Carum Carvi, Linn.
Chenopodium/

Chenopodium opulifolium, Schrad.
Cicer soongaricum, Steph.
Cynanchum Roylei, Wight.
Cynoglossum micranthum, Desf.
 " *Wallichii*, G. Don.
Dianthus angulatus, Royle.
Dictamnus albus, Linn.
Emilia sonchifolia, DC.
Erysimum hieracifolium, Linn.
Impatiens brachycentra, Kar.
Leptorhabdos Benthamiana, Wall.
Lespedeza dubia, Schindler.
 " *floribunda*, Bunge.
Nepeta discolor, Royle.
Pimpinella diversifolia, DC.
Rubia cordifolia, Linn.
Salvia glutinosa, Linn.
Selinum vaginatum, Clarke.
Senecio chrysanthemoides, DC.
 " *pedunculatus*, Edgew.
Verbascum Thapsus, Linn.
Veronica arvensis, Linn.
 " *Beccabunga*, Linn.

(b) Confined to arid zone deodar.

Adonis scaberculata, Boiss.
Arenaria Festucoides, Benth.
 " *foliosa*, Royle.
Hyssopus officinalis, Gay.
Nepeta supina, Stev.
Onosma echioides, Linn.
Rheum Emodi, Wall.
Silene Griffithii, Boiss.
Silene Kunawarensis, Royle.
Tanacetum senecionis, Gay.

C. Climbers (Common to both zones)

Clematis montana, Buch - Ham.
Clematis orientalis, Linn.

D. Ferns. (Confined to arid zone)

Asplenium/

Asplenium fontanum, Bernh.
Asplenium Trichomanes, Linn.

E. Grasses (Common to both zones)

Agropyron longearistatum, Boiss.
Agrostis alba, Linn.
" Royleana, Trin.
Stipa sibirica, Lam.
Setaria viridys, Beauv.
Perotis latifolia, Ait.

T Y P E S X and X I I I.

DRY ZONE SILVER FIR - BLUE PINE AND ARID
ZONE BLUE PINE FORMATIONS.

The blue pine (Pinus excelsa) replaces both the kharsu oak and the silver fir as the typical high level tree of the inner valley, and at 10,000-12,000 feet it extends as far towards the arid Tibetan uplands as deodar does. Below this level the pine occurs quite frequently as a companion of deodar and spruce in the dry zone and with deodar in the arid zone, but its general tendency is to retreat uphill with increased aridity, depending more and more upon the long-lying snow beds of the colder northern aspects for its moisture supply.

Silviculturally this high level blue pine is quite different from the low level type of the monsoon zone, as it forms very open stands on gentle slopes which hold the snow well, while the monsoon type prefers warm well-drained ridges. Ecologically also the two types of blue pine are separate, for the dense crops of pure blue pine in the monsoon zone are merely a seral phase in the reclothing of slopes from which the forest has been expelled by fires, and leading/



HIGH-LEVEL BLUE PINE in DRY ZONE.

- (45) 20-year old sapling crop which has occupied a snow lane carved out of the older forest by an avalanche; Mehbar, 10,000 feet.
- (46) Typical isolated blue pine of Chini uplands, showing "witches' brooms" caused by Arceuthobium attack.



leading back to the climax forest type of deodar which will in due course return. The high level blue pine on the other hand is a true climatic climax type for the very specialised conditions in which it grows and there is no other species except scrub juniper which could take over its role on the arid alpine tracts.

Unfortunately, it is in the dry and arid zones that the loranthaceous parasite Arceuthobium minutissimum, Hk. is doing very serious damage to the blue pine. Many of the blue pine stands between 10,000 and 12,000 feet have been seriously depleted by this pest in areas where the pine is the only check against avalanches and snowslides.

The Kharsu oak only appears in the high level belt of the dry zone in a few places in the Panwi and Baspa forests and its place is taken by the silver fir and the blue pine. The silver fir persists much further into the arid zone than the oak, particularly the more xerophytic form, Abies spectabilis, Spach. which is found on the slopes of Kailas and above Rogi, but it is seldom as common as the blue pine, which eventually displaces it altogether.

Towards the Tibetan border the associates of the blue pine become more and more typical of the true Tibetan flora, as will be seen from the species listed/



ARCEUTHOBIUM ATTACK on DRY ZONE BLUE PINE.

- (47) Close-up of pine sapling covered with pustules of Arceuthobium, and with badly swollen branches and stem.
- (48) Blue pine on right killed by parasite, and on left reduced to a fastigiate bush.



listed below under "(c) confined to arid zone". The varied herb flora of the alpine grass lands of the middle dry zone persists up to approximately the Teti Valley, and is closely associated with the open blue pine stands throughout Lower Chini.

VEGETATION LIST FOR SILVER FIR - BLUE
PINE AND ARID ZONE BLUE PINE
FORMATIONS.

A. Trees and Shrubs.

(a) Common to both dry and arid zone blue pine.

- Abies Pindrow, Spach.
- * " spectabilis, Spach.
- Betula utilis, D.Don.
- Cotoneaster microphylla, Wall.
- Juniperus communis, Linn.
- Picea Smithiana, Boiss.
- Pinus excelsa, Wall.
- Potentilla eriocarpa, Wall.
- " fruticosa, Linn.
- Polygonum amplexicaule, D.Don
- " vacciniifolium, Wall.
- Pyrus foliolosa, Wall.
- Ribes Grossularia, Linn.
- Ribes orientale, Desf.
- Rhododendron Anthopogon, D.Don.
- " campanulatum, D.Don
- Rhamnus prostrata, Jacquem.
- Rubus purpureus, Bunge.
- Rosa Webbiana, Wall.
- Salix denticulata, Anders.
- " flabellaris, Anders.
- " hastata, Linn.
- Thymus Serpyllum, Linn.
- *Astragalus Candolleanus, Royle.
- " pedunculatus, Royle.
- " rhizanthus, Royle.

(b) Confined to dry zone.

- Betula alnoides, Buch - Ham.
- Cotoneaster bacillaris, Wall.
- Elscholtzia polystachya, Benth.
- Hippophae rhamnoides, Linn.
- Hypericum cernuum, Roxb.
- Lonicera hispida, Pall.
- Pyrus/

Pyrus Aucuparia, Ehrh.
Rhododendron lepidotum, Wall.

(c) Confined to arid zone.

Artemisia maritima, Linn.
Astragalus leptocentrus, Bunge.
 " *polyacanthus*, Royle.
 " *strobiliferus*, Royle.
 " *Webbianus*, Grah.
Caragana Gerardiana, Benth.
 " *sukiensis*, C.K. Sehn.
 " *versicolor*, Benth.
Cotoneaster nummularia, Benth.
Ephedra Gerardiana, Wall.
Eurotia ceratoides, C.A. Mey.
Juniperus macropoda, Boiss.
 " *pseudosabina*, Fisch.
Lonicera spinosa, Jacquem.
 " *obovata*, Royle.
 " *purpurascens*, Walp.
Myricaria germanica var. *prostrata*, Desf.
Pinus Gerardiana, Wall.
Polygonum paronychoides, C.A. Mey.
Potentilla ambigua, Camb.
 " *micropetala*, D. Don
 " *rigida*, Wall.
 " *Salesoviana*, Stoph.
Salix hastata, Linn.

B. Herbs.

- (a) Common to both dry and arid zone
 blue pine, but restricted to the
 region of alpine grasslands
 (approximately, up to Teti Gad).

Aconitum heterophyllum, Wall.
 " *Lycoctonum*, Linn.
Anaphalis cinnamomea, Clarke.
 " *nubigena*, DC.
 " *triplinervis*, Clarke.
Anemone obtusiloba, D. Don.
 " *narcissiflora*, Linn.
 " *polyanthes*, D. Don.
Angelica glauca, Edgew.
Arctium Lappa, Linn.
Arisaema/

- Arisaema intermedium*, Blume.
 " *Jacquenmontii*, Blume.
 " *Wallichianum*, Hk.
Aster molliusculus, Wall.
Boenninghausenia albiflora, Reichb.
Bupleurum Candollii, Wall.
Bupleurum tenue, Buch - Ham.
Campanula latifolia, Linn.
Cassiope fastigiata, D. Don.
Cicer soongaricum, Steph.
Crepis sibirica, Linn.
Cucubalus baccifer, Linn.
Cynoglossum furcatum, Wall.
Cynoglossum micranthum, Desf.
 " *Wallichii*, G. Don.
Delphinium denudatum, Wall.
 " *vestitum*, Wall.
Emilia sonchifolia, DC.
Erigeron alpinus, Linn.
Fragaria vesca, Linn.
Galium Mollugo, Linn.
Gentiana argentea, Royle.
 " *capitata*, Buch - Ham.
 " *Kurroo*, Royle.
 " *tianshanica*, Rupr.
Geranium nepalense, Sweet.
 " *Robertianum*, Linn.
 " *Wallichianum*, D. Don.
Geum elatum, Wall.
 " *urbanum*, Linn.
Halenia elliptica, D. Don.
Impatiens scabrida, DC.
Iris kumaonensis, Wall.
 " *nepalensis*, Don.
Lactuca Scariola, Linn.
Leontopodium alpinum, Cass.
Lespedeza Gerardiana, Grah.
 " *juncea*, Pers.
Lotus corniculatus, Linn.
Meconopsis aculeata, Royle.
Morina Coulteriana, Royle.
 " *longifolia*, Wall.
 " *persica*, Linn.
Myosotis cespitosa, Sch.
 " *sylvatica*, Hoffm.
Nepeta discolor, Royle.
Nepeta Clarkei, Hk.
Orobanche Epithymum, DC.
Oxytropis mollis, Royle.
Parnassia nubicola, Wall.
Pedicularis/

Pedicularis macrantha, Klotsch.
 " *megalantha*, D.Don.
 " *pectinata*, Wall.
Phlomis bracteosa, Royle.
Pleurospermum Brunonis, Benth.
Polygonum affine, D.Don.
 " *molle*, D.Don.
Potentilla argyrophylla, Wall.
 " *nepalensis*, Hk.

HERBS (~~Common to both dry and arid zone blue pine etc~~)
~~contd.~~

Primula denticulata, Sm.
Ranunculus hirtellus, Royle.
Roscoeia spicata, Sm.
Saussurea taraxacifolia, Wall.
Sedum Ewersii, Ledeb.
Senecio chrysanthemoides, DC.
 " *graciliflorus*, DC.
Taraxacum officinale, Wigg.
Tanacetum nubigenum, Wall.
Thermopsis barbara, Benth.
Trigonella corniculata, Linn.
 " *Emodi*, Benth.
Veronica arvensis, Linn.
 " *Beccabunga*, Linn.
Vicia ridigula Royle.

(c) Extending to arid zone beyond Teti Gad.

Adonis scrobiculata, Boiss.
Allium atropurpureum, Waldst.
Androsace sarmentosa, Wall.
Arenaria festucoides, Benth.
 " *foliosa*, Royle.
Hyssopus officinalis, Gay.
Lactuca Lessertiana, Clarke.
Nepeta supina, Stev.
Onosma echioides, Linn.
Paraquilegia grandiflora, Drum.
Primula rotundifolia, Wall.
Rheum Emodi, Wall.
 " *spiciforme*, Royle.
Rumex hastatus, D.Don.
Saxifraga Stracheyi, Hk.
Scrophularia variegata, Bieb.
Tanacetum/

^a
Tanacetum senecionis, Gay.

C. Grasses and Climbers.

As for dry and arid zone deodar.

D. Ferns. (common to both dry and arid zones up to Teti Gad)

Osmunda Claytoniana, Linn.

Pteris aquilina, Linn.

TYPE XIV. SERAL COMMUNITIES OF DRY AND
ARID ZONES.

In the upper valley there is no great pioneer forest community such as the blue pine is in the moist zone, and much of the old lower deodar belt which was destroyed by traders 70 years ago is still open grassland. In the drier climate the recolonisation process is very slow and the deodar and the blue pine have on the other hand a constant struggle to maintain their ground. Possibly if the browsing and lopping in the arid zone were less intense, Pinus Gerardiana and Quercus Ilex would recolonise part of the lower slopes, but under present conditions they are incapable of doing so. The Ilex oak is lopped so heavily along its lower belt that reproduction has failed and the forest is in many/

many places retreating uphill, while the seed of the neoza is so much sought after for food that it has little chance of regenerating itself profusely. In the upper forest belt also the blue pine is suffering so severely from the Arceuthobium attack that in many places it also is retreating and in some areas is dying out altogether, but where it is not suffering so severely it is still capable of re-establishing itself on typical forest land above 9,000 feet.

In the silver fir - blue pine belt of Kilba range large areas have been given up for summer cultivation between 9,500 and 11,000 feet and the forest has been destroyed to make way for catch-crops of buckwheat. Where unduly large blocks have been cleared in this way erosion of the exposed soil has set in very quickly and some of those clearings only a few years old are already ravining badly where the land has not been terraced.

Under dry conditions the plants which are most useful in recolonising screes and snow slides are the following:-

SHRUBS/

SHRUBS.

Artemisia maritima, Linn.
 " *vulgaris*, Linn.
Astragalus anomalus, Bunge.
 " *graveolens*, Buch.-Ham.
Desmodium nutans, Wall.
Plectranthus rugosus, Wall.
Polygonum paronychioides, C.A.May
Rosa Webbiana, Wall.
Rubus purpureus, Bunge.
Spiraea Lindleyana, Wall.
Thymus Serpyllum, Linn.
Viburnum cotinifolium, D.Don.

HERBS.

Chenopodium opulifolium, Schrad.
Cynoglossum Wallichii, G.Don.
Dianthus angulatus, Royle.
Emilia sonchifolia, DC.
Impatiens brachycentra, Kar.
Leontopodium alpinum, Cass.
Leptorhabdos Benthianiana, Walp.
Nepeta supina, Stev.
Onosma echoides, Linn
Oxytropis mollis, Royle,
Picris hieracioides, Linn.
Rumex hastatus, D.Don.
Salvia glutinosa, Linn.
Saxifraga Stracheyi, Hk.
Silene Griffithii, Boiss.
Sisymbrium Alliaria, Scop.
 " *strictum*, Hk.
Verbascum Thapsus, Linn.

CHAPTER VIII.

ANALYSIS OF ECOLOGICAL VALUE OF COMMON PLANTS.

RANUNCULACEAE.

CLEMATIS.

Several species occur as woody climbers throughout Bashahr moist zone, mostly as hedge plants on open hillsides, e.g. C. grata, Wall., C. graveolens, Lindl., C. connata, DC., and C. Buchaniana, DC. The last two are also found in forest undergrowth, often climbing on Indigofera and Lonicera, and indicating usually a hot aspect or a hole in the canopy.

C. barbellata, Edgew. is a true forest plant and is found frequently in deodar-spruce and ban oak - Rhododendron undergrowth.

C. montana, Buch-Ham. is common in the moist zone, but also occurs in dry deodar as a densely matted ground cover, and in such situations it may be taken as an indicator of a dry hot soil in areas having a very light dew-fall - e.g. Wadang, which is bone-dry on mornings when other Baspa soils have been moistened by dew.

C. orientalis, Linn. is a common hedge climber in the dry zone in the neighbourhood of cultivation at 10-12,000 feet.

ANEMONE.

Anemone rivularis, Buch-Ham. is common in lush meadows above 7,000 feet and where it occurs in deodar may be taken to indicate an unusually moist top-soil, - e.g. in Barang 37c a village water-channel runs diagonally across the forest at about 9,000 feet, and A. rivularis is frequent along the banks and for 200 feet below the channel.

Anemone obtusiloba, D. Don and polyanthes, D. Don are also found in lush meadows, but are more typical/

typical of unirrigated alpine pasture lands and scattered blue pine where the forest gives place at its upper limit to open pastures (Urni and Chini "Kanda" at 12,000 feet.)

Anemone narcissiflora, Linn. is quite common near water channels in the dry and arid zones, but is not as common in deodar forest as the above.

THALICTRUM.

This is a most valuable genus in deodar ecology and for this purpose the species T. minus, Linn., T. javanicum, Blume., and T. foliolosum, DC. may be treated as one. Their specific differences are small, their distribution is common, and their ecological characteristics are similar. They occur as an almost constant undergrowth to deodar within the whole of its distribution up to the scattered deodar - blue pine forests of the arid zone, but they avoid the lower deodar fringe where the deodar gives way to chil pine in the moist zone and neoza in the dry zone.

In the upper limits of the deodar in the moist and dry zones the Thalictrum gives way to the subalpine ground flora of the spruce and Kharsu oak forests, and within the main deodar and blue pine areas it gives place to plants of ranker growth wherever damp reentrants or hollows occur. It is thus a valuable indicator of true deodar site quality.

These Thalictrums are all sensitive to excessive heat and disappear rapidly from any disforested ground owing to exposure; and when persisting in the open they have a wilted and unhappy appearance. Healthy Thalictrums of these species can therefore be taken as a fairly reliable indication that soil and light conditions are favourable for deodar reproduction. As Thalictrum even in dense masses is not heavy enough to check the germination and development of deodar seedlings, its occurrence in any large quantity and in conjunction with Fragaria vesca, Valeriana Wallichii, Viola spp., and Indigofera in the middle deodar zone (Nihar to Barang) shows that deodar may safely be opened up under regular shelterwood markings.

Thalictrum reniforme, Royle, (neurocarpum, Royle) is of a much ranker growth form than the T. minus.

T. minus type, and is typical of the damper deodar-spruce forests, along with Adiantum fern, Ainsliaea, Chaerophyllum, and Polygonatum.

ADONIS.

A. aestivalis, Linn. occurs as a common field weed in cultivation in the moist and dry zones and A. scrobiculata, Boiss. similarly in the more arid parts, occasionally being found in forest undergrowth.

RANUNCULUS.

Royle

The three species R. hirtellus, R. laetus Royle., and R. arvensis, Linn. all occur in meadow lands and indicate considerable surface moisture. Towards the arid zone they are confined strictly to irrigated surfaces such as the banks of running streams and marshy lush meadows.

Caltha palustris, Linn. is similar to Ranunculus, but is more definitely associated with marshes and swampy meadows, often growing below Salix denticulata at the water's edge in dry zone deodar and blue pine neighbourhoods.

Aquilegia pubiflora, Wall. is usually associated with Ranunculus spp. and Anemone rivularis on banks of water channels in the dry zone, but also occurs sporadically far from water and on exceedingly dry and hot ground such as the patches of soil between boulders on dabbar ground (old rock avalanches more or less stabilised).

Paraquilegia grandiflora, Drum. is fairly common on rocks at about 12-14,000 feet in the arid zone, and occasional amongst the very arid blue pine where the forest reaches 12,000 feet.

DELPHINIUM.

D. denudatum, Wall. and D. vestitum, Wall. are both typical of open pasture lands where such occur immediately above deodar - blue pine and deodar-spruce forests at 10-12,000 feet. D. denudatum may be found fairly frequently at lower elevations as an occasional plant in forest undergrowth, but it is so erratic that it is of little ecological value.

ACONITUM./

ACONITUM.

A. Lycocotum, Linn. and A. heterophyllum, Wall. both occur sporadically in moist forest types and also in the moister alpine pastures but neither are frequent enough to be of use as indicators.

MAGNOLIACEAE

Schizandra grandiflora, Hk. is a common woody climber in moister deodar-spruce forest and also on cliff faces when moisture is seeping through the clefts.

BERBERIDACEAE

BERBERIS.

B. petiolaris, Wall. is common throughout moist and dry zone both in shady forest undergrowth and in open shrubby places.

B. Lycium, Royle frequents a fairly dry type of undergrowth under open canopy in moist deodar and blue pine forests.

B. aristata, DC. and B. pseudumbellata, Parker are very common in the dry middle zone both in open shrubby places and under deodar canopy, pseudumbellata reaching its best development in the Baspa and Bhabba valleys and forming dense masses of undergrowth with Rhamnus, Rosa, and Abelia.

B. Edgeworthiana, C.K. Schn. and B. Jaeschkeana, C.K. Schn. occur in the dry and arid zones as scattered bushes in very dry forest or in denser patches in open shrubby places along with Lonicera hypoleuca.

Speaking generally, the presence of Berberis in any quantity in forest undergrowth indicates a tendency towards dry top-soil conditions. This is particularly/

particularly so in the moister zones, whereas in the dry and arid zones Berberis tends to rise in the social scale and join the better classes of deodar associates. The Berberis species of the moister forest types, such as petiolaris and Lycium, also tend to invade the dry and even the arid climatic zones wherever the deodar is found making better development, e.g. Purbani and Kashang Gad.

Podophyllum Emodi, Wall. is restricted to moist and very thoroughly shaded ravines in moister deodar-spruce and Kharsu oak forests.

PAPAVERACEAE

Meconopsis aculeata, Royle is purely an alpine and is confined to open pastures above the tree limit in Chini and Kailas ranges, very occasionally mingling in the top fringe of the high level blue pine.

Papaver dubium, Linn. is a common field weed amongst crops but is seldom found elsewhere.

FUMARIACEAE

Corydalis. Several species occur as common field weeds, particularly in rough cultivation which is ploughed only every third or fourth year - e.g. C. Govaniana, Wall., C. ramosa, Wall., and C. cornuta, Royle. The last two are also found as hedge plants and C. ramosa is a rampant weed in Shoang deodar nursery in the Baspa.

Corydalis rutaefolia, DC. is found with the above and also as an undergrowth in damp spruce forest.

CRUCIFERAE/

CRUCIFERAE

Barbarea vulgaris, R. Br.
Arabis perfoliata, Lam.
Arabis alpina, Linn.
Capsella Bursa-pastoris, Medic.
Thlaspi arvense, Linn.
Cardamine hirsuta, Linn.

These are all fairly common field weeds throughout Kanawar, and are also found as escapes in rough pasture land but seldom in close forest.

Sisymbrium strictum, Hk.
Sisymbrium Alliaria Scop.
Erysimum hieracifolium, Linn.

Frequently found in dry sandy soil below thin canopies of Pinus Gerardiana and deodar in the dry zone.

CAPPARIDACEAE

Capparis spinosa, Linn. is a scrambling climber fairly common on the hot rocks of the Suttlej gorge and old avalanche scree below 8,000 feet. It is typical of the recurrence of Punjab plains and Salt Range species in the arid gorges of the Tibetan border - e.g. Withania coagulans, Zanthoxylum alatum, and Olea cuspidata, but it extends further into the arid zone than any of these.

VIOLACEAE

Viola Patrinii, Ging. and V. serpens, Wall. These two species appear to be interchangeable throughout the moist and dry zone, but are each locally dominant to the exclusion of the other in certain forests - e.g./

e.g. V. Patrinii is dominant around Nichar in deodar-spruce and V. serpens in deodar-blue pine at Dippi. When occurring along with Fragaria vesca and Adiantum fern, as they frequently do, they may be taken to indicate well stabilised top soil with abundant moisture where heavy opening of the forest canopy will be almost certainly followed by rampant weed growth. Along with Fragaria, Thalictrum, and well grown Indigofera bushes the Viola is an indication of optimum growth for deodar.

POLYGALACEAE.

Polygala abyssinica, R. Br. and P. chinensis, Linn. are occasionally found in warm pasture lands below the forest at about 6,000 feet in the moist zone.

CARYOPHYLLACEAE.

Dianthus angulatus, Royle is common through Chini and Kailas where deodar conditions alter from dry to arid - i.e. on the hot slopes of Rogi and Poari where canopied forest gives way to open parklike deodar, and along the lower limit of canopied deodar; and where neoza pine becomes dominant at the expense of deodar, and also where Roylea Galycina and grasses of park-like deodar give place to the Artemisia maritima socies of the river gorge. Where it occurs in quantity in the open it can be taken as indicative that arid conditions are improving and that the neighbourhood may be expected to grow deodar of sorts. On the other hand when it occurs under existing deodar stands, it is a valuable indication that side shade in the direction of the particular site's hottest sun is essential for regeneration purposes and that a slow selection method is the best for marking.

SILENE./

SILENE.

Silene Cucubalus, Wibel. and S. conoidea, Linn. - Common weeds often found in open ground in and around moist deodar forests.

Silene Griffithii, Boiss. displaces the above Silene species in drier deodar forest types of Kilba and Kailas.

Silene kunawarensis, Royle displaces S. Griffithii under arid conditions and is found sporadically in pureneoza forest and in the open socies of Kailas avalanche screes.

Cucubalus baccifer, Linn. is a scrambling herb of subalpine pastures and open deodar blue pine forest of dry zone.

Cerastium glomeratum, Thuill., and Lychnis indica, Benth. - common weeds of roadside and waste ground in the hotter parts of the Suttlej gorge, and occasionally reaching up to 10,000 feet. They are a useful indication that grazing is heavy in the vicinity as their seed is apparently spread in the fleeces of goats and sheep, and they are always commonest in the immediate neighbourhood of graziers' camping grounds.

Stellaria spp. (chiefly S. crispata Wall.) - common ground plants of damp deodar-spruce forests, penetrating towards the arid zone wherever this formation occurs.

Arenaria. The Arenarias are not true forest plants, but are mentioned here because their specific distribution is so closely related to climatic differences - e.g. A. serpyllifolia, Linn., the common inhabitant of rock crannies of the moister hills, is replaced in the dry and arid zones by A. foliosa, Royle and A. festucoides, Benth.

TAMARICACEAE

Myricaria Elegans,/

Myricaria elegans, Royle is a common shrub along stream beds of the Suttlej tributaries in the dry and arid zones - e.g. Baspa, Kashang and Tidong, along with Hippophae.

Myricaria germanica, Desv. occurs as an upright shrub with M. elegans along stream beds, while its var. prostrata is definitely an arid zone plant confined to the bleak waterless alpine plateaux of the Tibetan border.

HYPERICACEAE

Hypericum cernuum, Roxb. and patulum, Thunb. both occur as shrubs on steep places such as stabilised rock falls and old avalanche scree in fairly damp localities of deodar-spruce, patulum being more definitely a moisture loving species. H. cernuum also reappears under the high-level blue pine of the Bhabba associated with Rosa sericea as a true forest plant.

STERCULIACEAE

Sterculia villosa, Roxb. occurs as a small tree in open forest along the hotter valley bottoms of the Suttlej and its tributaries in the moist zone below 6,000 feet. It associates with Mallotus, Woodfordia, Lannea, and Erithrina in the hot lands below the chil forest, and on drier areas than Dalbergia Sissoo. 41

GERANIACEAE

Geranium/

GERANIACEAE

Geranium Wallichianum, D. Don and G. nepalense, Sweet are typical of water channel banks and well watered ground such as lush meadows, associated with Anemone rivularis and Pedicularis spp. They also occur in unirrigated pasture land in and around the upper deodar limit and the high level blue pine, and in such cases their growth-form reacts rapidly to lack of water, being very scraggy and with greatly reduced leafage where surface moisture is scarce.

G. Robertianum, Linn. is less demandative in its water requirements and is a fairly frequent member of rough pasture communities under high level blue pine along with Cynoglossum Wallichii.

G. ocellatum, Jacquem. and Erodium cicutarium, L'Herit. occur commonly in field terraces and near cultivation in the moist zone.

Oxalis corniculata, Linn. is a very common member of rough pasture communities along with Androsace rotundifolia and Lactuca dissecta, typical of the low level hot pasture lands below 7000 ft. so common on the southern exposures of the Pandrabis valleys adjoining the Sutlej gorge.

Impatiens. The balsams form a most interesting group, as they are a very noticeable feature in several forest and field communities. The usual type of balsam growth is a dense mass of coarse stems growing rampantly along the banks of mill streams and water channels throughout Kanawar moist and dry zones, and flourishing even in the arid zone when irrigated sufficiently frequently. This type includes I. Roylei, Walp., I. Thomsoni, Hook., I. gigantea, Edgew., I. amplexicaulis, Edgew., I. scabrida, D C., I. amphorata, Edgew., I. racemosa, D C. and I. laxiflora, Edgew.

All these species are well distributed from the unirrigated fields of the monsoon area to the dry zone of Chini and Kailas Ranges. Most of them also occur fairly frequently in the dry zone away from water in rough pasture land, but here they are very much reduced in size and appearance. I. scabrida is the commonest in damp forest reentrants, often mixed with Strobilanthes.

Impatiens/

Impatiens micranthemum, Edgew. is, as far as I have observed, restricted to the irrigated fields of the warm Suttlej valley in the arid zone below 8,000 feet and is seldom found in natural forest.

Impatiens brachycentra, Kar. is a much smaller plant than any of the above, and is not a typical balsam. It is, however, the most useful of the Impatiens in deodar ecology, because it is found constantly as a frail but quick-growing annual herb on the dry hot sandy lands of the deodar-neoza type. It disappears at once where Artemisia or Plectranthus come in and its presence in any quantity seems to suggest that for that type of xerophytic forest the canopy and conditions are good.

RUTACEAE

Boenninghausenia albiflora, Reichb. is a common member of communities typical of fairly moist warm, but shady conditions in deodar-blue pine and deodar-spruce - e.g. Panwi Forest.

It also occurs in wetter portions of the Pandabis Aesculus forest along with Litsea, Sarcococca and Galium, and again it appears in the drier type of subalpine pasture land adjoining high level blue pine forest along with Thermopsis barbata and Potentilla atropurpurea, but this latter is a very much reduced plant which is possibly a distinct variety with a smaller size, smaller flowers and much reduced leaf surface.

Dictamnus albus, Linn. has a curious distribution, as it usually occurs in pure and fairly dense patches in open and warm situations below 9,000 feet - e.g. amongst scattered Pyrus trees below Jani village, and on sandy open deodar ground below Mehbar village (dry zone).

Zanthoxylum alatum, Roxb. occurs in sporadic shrub groups along the bottom of the Suttlej gorge at Wangtu and Sholtu, but only within a few hundred feet of the river, as if it were dependent upon air moisture. It is another of the outer foothills species which has emigrated or persisted along the valley bottoms of the inner hills, c.f. Olea cuspidata.

Skimmia/

Skimmia Laureola, Sieb. is common and markedly gregarious in damp shady forest undergrowth usually in the close company of Litsea umbrosa, and Sarcococca saligna, under the canopy of Quercus incana and Rhododendron arboreum i.e. in areas just too damp and shady to carry regular deodar crops although in such places individual deodar trees frequently reach enormous proportions. At higher elevations it is fairly common in moist spruce-deodar forest along with Daphne papyracea.

SIMARUBACEAE.

Picrasma quassioides, Benn. occurs infrequently as a large shrub in the mixed broad-leaved forests of moister Pandrabis about 6,000, - 7000 ft. but has no direct relationship with deodar.

MELIACEAE.

Melia/

MELIACEAE.

Melia Azedarach, Linn. occurs in small pure groups in the neighbourhood of villages in and near the hot valley bottoms of the moist zone below 7,000 ft. and less frequently in the dry zone - e.g. Chini at 8,000 ft. where it has almost certainly been introduced. It is not of much value as a deodar indicator though it shows how closely the average temperatures of the hotter valley bottoms of the inner hills must approximate to the semi-tropical conditions of the outer foothills.

Cedrela Toona, Roxb. occurs in the more sheltered hollows of the hot ground along the Sutlej valley bottom below the chil belt. In a few restricted areas of this type it reaches large dimensions (75 ft. high and 6 ft. in girth near Jakri), but elsewhere it is too heavily lopped to grow to any size. Its escape from lopping in these few places must be due to its height growth rendering it difficult to climb and also to its companionship with heavily lopped species such as Albizzia Julibrissin and Bauhinia variegata.

Cedrela serrata, Royle is referred to Cedrela Toona, Roxb. in "Index Kewensis" but silviculturally they are quite separate species. This is a common tree in warm but moist valley bottoms up to 7,000 ft. and is also found less frequently on more open hillsides up to 8,000 ft. where the surface is broken and rocky but moist below, - e.g. Lishnam Compartment 12 along with Rhus succedanea and punjabensis, Deutzia corymbosa, and Spiraea Lindleyana on the edge of good deodar forest but where moisture conditions produce too luxuriant a flora for deodar to establish itself readily except by expensive planting and weeding.

ILICACEAE.

Ilex diphyrena, Wall. occurs in damp forest at 6000-8000 feet, generally in the transitional stage between pure deodar and the damper type of Litsea-Sarcococca shrub layer in the Aesculus or Ulmus-Cornus forests. Ilex generally occurs along with Cotoneaster bacillaris, Berberis Lycium, and Lonicera angustifolia, but is not so widely met with as any of those three owing probably to its more exacting requirements for shade and moisture.

CELASTRACEAE./

CELASTRACEAE.

Euonymus tingens, Wall. and E. Hamiltonianus Wall. both occur as members of an elusive broad-leaved forest type which is closely related to the typical Ulmus-Cornus community of the damp thach or hollow, too damp for conifers to persist in. These Euonymus species often form pure groups between the deodar - blue pine and the true thach broad-leaved forest, or occur mixed with Acer where the true thach type does not occur - e.g. in the upper reaches of the Bhabba where the Euonymus is heavily lopped.

Euonymus lacerus, Buch. Ham. (grandiflorus, Wall.) is a shrub which is found frequently in the damper deodar-spruce type, and persisting with this type far into the dry zone. It is not sufficiently common or regular in its occurrence to be of much use as an indicator, however.

RHAMNACEAE.

Zizyphus rotundifolia, Lam. (nummularia DC.) and Z. oxyphylla, Edgew. are restricted to the bottom of the Sutlej gorge and are not found higher up the river than Jakri.

Berchemia lineata, DC. is a deciduous shrub found occasionally on shady rocky ground in the Baspa, but is not of any importance ecologically.

Rhamnus virgata, Roxb. (dahurica, Pall.) is a useful indication of drought conditions under thin canopies of deodar and blue pine, showing that liberties must not be taken as the forest floor is unduly dry. This applies to the Bhabba and Sholtu-Kilba forests where it is frequently found under conifer crops along with Caragana brevispina, Berberis Lycium, Jasminum, and Abelia. When it occurs along with larger quantities of Indigofera and Desmodium, as it occasionally does on ground where the moisture is better conserved, felling may be correspondingly heavier, but the presence of R. virgata in any large amount should be looked upon as a danger signal for deodar regeneration work.

Rhamnus purpurea, Edgew. is frequently found as/

as a gregarious shrub in moist ravines up to 10,000 ft. but its distribution is very erratic.

Rhamnus prostrata, Jacquem. is a common member of open alpine and sub-alpine communities on heavily grazed rocky ground in the dry and arid zones, but it is seldom found in close forest.

Sageretia theezans, Brongn. is occasionally found on the hot lower slopes of the main Sutlej valley but seldom in close forest.

VITACEAE.

Vitis vinifera, Linn., the cultivated grape, was grown in great quantities in the drier parts of the valley beyond Nichar at one time, but the vine disease has reduced grapegrowing since 1860 to just an occasional small garden along the main valley below 7,000 ft. The area in which grape growing succeeded best, corresponded closely with the limits of the neoza pine. In the Forest Department garden at Sholtu, the grape flourishes well under the very light shade of open rows of Eucalyptus Globulus, and on the same riverain terrace a deodar plantation now about 54 years old has done very well.

Of the wild vines the following are all found climbing on tree trunks to great heights and also as rock climbers in the moist zone : V. lanata, Roxb., V. flexuosa, Thunb. (parvifolia, Roxb.) V. divaricata, Wall., and capreolata, D. Don. in the deodar-spruce up to 9,000 ft. and V. semicordata, Wall. in the higher spruce and silver fir. These vines are fairly strictly confined to the moist zone, and do not continue into the dry zone as so many of the typical deodar companions do, - e.g. Tangach at the entrance to the Bhabba valley is about the last place where vines are a distinctive feature, and even here it is as a rock climber and not as a tree climber that V. divaricata is well developed at 8,000 ft.

SAPINDACEAE.

Staphylea Emodi, Wall. is typical of the damper parts of the lower deodar belt in the dry zone and is generally associated with Rhus punjabensis and succedanea, Caragana brevispina and Berberis Lycium - e.g. small broad-leaved species in Ramni forest/

forest at about 7,500 ft. in which the only forest tree reproduction established was a good crop of walnut saplings.

Acer. The maples form an interesting study in their moisture requirements as their typical habitat is on the edge of a damp broad-leaved thach, intermediate between the deodar-blue pine or deodar-spruce and the Ulmus-Cornus-Corylus crops of the thach itself. They are also found in a similar intermediate position in the higher spruce belt as an understorey to scattered spruce trees and forming with them a societ which is intermediate between the Abies-Picea-Arundinaria falcata, in which the fir reaches its highest development, and the Quercus semecarpifolia which forms a dense pure forest on the damper ground flanking the well drained spurs. Of these maples A. Caesium, Wall. and A. pictum, Thunb. are the commonest, and A. acuminatum, Wall. and A. villosum, Wall. are less frequent though still fairly common and occasionally the dominant species in restricted localities. Ecologically however there is very little difference between them all, except that A. caesium penetrates further into the arid zone than the others e.g. it occurs in ravines separating deodar-bearing spurs in the Tidong valley at 9,500 ft.

Acer pentapomicum, Stew. is the true dry zone maple, as it is met with only on the hot lower slopes of the Baspa and of the main Suttlej valley above its junction with the Baspa and seldom above 7,500 ft. It is fairly gregarious on such hot slopes and associates usually with Fraxinus zanthoxyloides, Villebrunea frutescens, Plectranthus rugosus, Spiraea Lindleyana, and to a less extent with Quercus Ilex and Parrotia Jacquemontiana - e.g. Raturang Falls in the Baspa and at Shongtong in the main valley.

Aesculus indica, Colebr. is found forming pure rest in certain areas of the Pandrabis glens about 8,000 ft. in fairly damp depressions, sheltered from the drying winds of the Suttlej gorge but getting considerably more sun than the typical mixed broad-leaved type of thach - i.e. the Aesculus ground faces due east while the mixed thach type faces the colder aspects of north east to west. Its ecological position is between the deodar-blue pine of the dry ridges and the Alnus-Corylus-Populus of the wetter depressions. The horse-chestnut is also found as a member of the mixed broad-leaved types in which walnut and elm are prominent, but even in these it shows a markedly gregarious tendency. It also occurs as scattered standards/

standards above a dense shrub growth of Litsea, Meliosma, and Machilus in Taranda range along with Carpinus faginea.

SABIACEAE

Meliosma dilleniaefolia, Walp. is an infrequent companion in the type of dense evergreen shrub association in which Machilus and Litsea are the commonest members - e.g. Paunda and Chaunda Gads in Taranda Range.

ANACARDIACEAE.

Rhus Cotinus, Linn. is a fairly common shrub under open stands of Pinus longifolia along the Sutlej valley bottom from Rampur to Wangtu, sometimes gregarious but more often mixed in open shrub jungle with Pistacia, Colebrookia, and Rhynchosia. When with those plants it represents a slight improvement over the Plectranthus - Buddleia type of scrub and indicates ground suitable for the chil pine.

Rhus semialata, Murr. and Wallichii, HK. are fairly common in moist ravines below 8,000 ft. but neither of them extend beyond the regular monsoon belt of the outer hills. They are not of much ecological use as there are many more typical members of the thach forest which occur more regularly, e.g. Pyrus, Pieris, Cornus, etc.,

Rhus punjabensis, Stew. and Succedanea, Linn. replace the above two species towards the dry zone and occur quite regularly in moist ravine associations from Nichar to Ribba. They usually occur in association with other small broad-leaved trees such as Cedrela serrata, and Staphylea Emodi, with scattered larger walnut and horse-chestnut and shrubs such as Caragana brevispina, Rosa sericea, and Desmodium tiliaefolium, on the fringe of good deodar forest. Occasionally also Rhus succedanea occurs in almost pure patches in little open glades within the true deodar forest, and in such ^{places} appears to be a seral community under which young deodar regeneration quickly becomes dominant again.

Pistacia/

Pistacia integerrima, Stew. (P. Khinjuk, Stocks) is a fairly frequent companion of Pinus longifolia and sometimes reaches 40 ft. in height and 8-9 ft. in girth in the hot open scrub land where open stands of chil pine give way to Mallotus and Plectranthus. The Pistacia is usually associated with Woodfordia, Erithrina, Desmodium nutans and Rhyncosia, but it also persists on the more precipitous cliffs with southern exposures on which "prickly pear" is the main feature. The Pistacia, however, goes rather further into the dry zone Suttlej gorge than either the chil pine or the Euphorbia and is occasionally found in the Olea-Fraxinus association as far up as Purbani.

Lannea grandis, Engl. (Odina Wooddier, Roxb), is associated with Sterculia villosa in open scrub jungle in the hot valley bottom below the chil pine belt, in both the main Suttlej valley and the mouth of the Sechi Gad near Jakri at 4,000 ft. but it is not as common as the Sterculia.

CORIARIACEAE.

Coriaria nepalensis, Wall. is occasionally found as dense pure patches of scrub in the warmer exposures of moist zone ravines below 8,000 ft., but sheltered from the dry Suttlej valley winds. It is generally in close proximity to Prunus cornuta in glades along the lower fringe of the blue pine, and these two probably serve as a seral community preceding the establishment of blue pine, because in many instances seedlings can be found developing in the shade of such scrub and pushing their way through to the sunlight.

LEGUMINOSAE.

Piptanthus nepalensis, Sweet. is an occasional but not very frequent undershrub of moist deodar-spruce and Quercus incana-Rhododendron arborescens forests and occurs as a handsome flowering shrub, showing its best development in a mixture of Pyrus pashia/

Pyrus Pashia, Pieris ovalifolia and Deutzia corymbosa with only light shade from the upper forest canopy. It is, however, not common enough to be of much service as an indicator.

Thermopsis barbata, Benth. is frequently met with in the drier types of subalpine pasture lands along with Potentilla atropurpurea, Anaphalis cinnamomea and Boenninghausenia, typical of the high level blue pine forests of the Bhabba and Chini between 10,000-12,000 ft. This type of scrub pasture is frequently found under open forest, but disappears directly the canopy becomes at all dense.

Trifolium. Various Trifoliums, chiefly T. resupinatum, Linn. occur commonly as field weeds and as members of permanent pasture on field terrace banks.

Parochetus communis, Buch-Ham. is locally common on the banks of water channels and streams in the moist zone - e.g. at 6,500 ft. in Daran Gad, and indicates plentiful and constant surface moisture.

Trigonella Emodi, Benth. and corniculata, Linn. are frequently found as components of the "leguminous turf" which occurs under open blue pine at about 10,000 ft. and which is typical of the abrupt change from deodar to blue pine which so frequently occurs at this level in the dry zone.

Medicago falcata, Linn. and several small wild Lucern species such as M. lupinula, Linn and denticulata, Willd. occur as fairly common members of better-class pasture land in the dry and arid zones, and along with Myosotis and Roylea in open park-like deodar at Rarang, - but their occurrence is so erratic that they have not been adopted as indicators.

Lotus corniculatus, Linn. is a very common field weed and also is a prominent member of permanent turf communities in fairly moist pasture lands. It also occurs along with Trigonella Emodi, Astragalus spp., Galium asperifolium, Bupleurum tenue, Nepeta supina, Impatiens brachycentra, and Thymus in the "leguminous turf" typical of arid zone forests at about 10,000 ft. where blue pine comes in above the deodar.

Indigofera/

Indigofera Gerardiana, Wall. including var. heterantha, Wall. could profitably be divided into two species for ecological work, as already suggested by Parker for morphological reasons:-

(i) I. Gerardiana is the large shrubby form with larger and fewer leaflets (9 - 17 leaflets, .4 - .5 inches long) which is closely associated with deodar throughout the dry zone. Its height growth alone is a clear indication of deodar quality, for in almost all of the very best deodar stands in the Upper Bashahr forests, this Indigofera reaches an unusual height - e.g. Ralli, Compartment 35, with very fine deodar stands and magnificent regeneration has Indigofera commonly 14 ft. in height: at Sangla, Compartment 27, the best deodar stands in the Baspa valley have got Indigofera commonly 10-12 ft. in height; Chota Kamba, Compartment 110 A, one of the few really good regeneration areas on the southern exposure, has got plenty of Indigofera of 8-10 ft. in height.

m One peculiar but quite definite type of this true Indigofera Gerardiana is found in the fine deodar forest of Boktu, Compartment 80b, (Chini range) where the leaves have almost invariably 9 leaflets of very uniform size, as compared with the usual tapering leaf with up to 17 leaflets.

(ii) I. heterantha is a much smaller plant, usually only 1-2 feet high with more leaflets (11 to 31 or even 33 per leaf), the typical leaflet being only .2 to .3 inches long. The whole appearance of the plant, including the size of inflorescence and pod, is very much reduced, and ecologically it is a plant of open sunny grasslands and hot rocky soil.

These two types are entirely different and are easily recognised in the field. As Parker had pointed out in his "Punjab Flora" that these forms required careful study, I gave this question considerable attention, but have been forced to conclude that owing to the vast number of intermediate gradations in form, it is impossible to prescribe any definite limits within which any one type can be segregated morphologically. Similarly from an ecological standpoint, there are the two extremes of - (a) fine height growth denoting good deodar conditions, and

(b) dwarf form showing lack of protection from heat and drought.

Between/



DEODAR REGENERATION STUDIES.

- (49) Advance growth in sapling stage in Purbani forest although much of forest is not yet regenerated.
- (50) Final fellings in Barang forest; refuse from sawing collected but cannot be burned as seedling crop is complete.



Between these extremes there are several easily recognisable community types in which Indigofera is prominent. The usual companions of Indigofera in these various types are:-

In best deodar areas :- Desmodium tiliaefolium, Thalictrum minus, Asparagus gracilis, Adiantum fern.

Average deodar blue pine areas:-
Desmodium tiliaefolium, Daphne papyracea, Spiraea canescens, Berberis spp., Salvia glutinosa, Smilax, Viola, Fragaria, and bracken fern.

Hot open pasture lands : Desmodium nutans, Salvia Moorcroftiana, Buddleia, Plectranthus, Artemisia, the coarser Compositae, and Andropogon and Eragrostis grasses.

I. Gerardiana has Desmodium as an almost constant companion and the similar way in which Desmodium tiliaefolium degenerates into the D. nutans type of the hot pastures is closely parallel both botanically and ecologically. The Desmodium is on the whole more widely distributed than Indigofera, although Indigofera persists further into the arid zone as a close companion of deodar wherever the latter finds suitable sites, e.g. Boktu and Kashang where Desmodium is very scarce.

Indigofera Dosua, Buch-Ham. is a fairly frequent companion of deodar in the dry zone in the open type of forest towards the bottom of the true deodar belt where open stands of rather poor quality occur with scattered neoza over a heavy scrub growth of bushes such as Desmodium tiliaefolium and D. nutans, Berberis spp., Cotoneaster bacillaris, Caragana brevispina, or Plectranthus rugosus.

Indigofera hebeptala, Benth. occurs irregularly in shady ravines in the moister deodar areas, generally in association with the Pyrus-Pieris-Rhododendron type.

Indigofera pulchella, Roxb. occurs in the chil pine belt of the lower Suttlej.

Caragana versicolor, Benth. (C. pygmaea, DC.) and C. Gerardiana, Benth. are common members of dry and arid zone alpine communities along with Juniperus communis, Berberis Jaeschkeana, Polygonum paronychioides and Cynoglossum Wallichii.

Caragana/

Caragana sukiensis, C.K. Schn. has been found at Nisang about 11,000 ft. along with Potentilla Salesoviana and Saxifraga Stracheyi on scree soil surfaces, but it is restricted to the arid zone alpine tract and is very infrequent even there. It is only mentioned here as additional evidence of the highly specialised arid alpine communities of the upper Suttlej.

Caragana brevispina, Benth, is a very common item in fairly dry deodar forest undergrowth, often gregarious in fairly dense patches, but also found with bracken, Salvia glutinosa, Rosa sericea, Rhamnus virgata, Berberis spp., Indigofera, and Desmodium. It is also frequent under very dry Ilex oak-neoza in a reduced and dwarf form, occurring in such places with Verbascum, Daphne oleoides, Thymus, and Leptorhabdos, and again as an occasional dwarf bush in the arid zone Fraxinus zanthoxyloides - Artemisia - Ephedra and Colutea-Lonicera hypoleuca types. As a deodar associate it denotes a very light canopy when it grows profusely, and reacts quickly to dense shade by becoming straggly and much reduced in leafage. A botanical variety frequent in some Taranda forests has leaves which have a strong silky pubescence on their upper surface, while the orthodox C. brevispina is glabrous above and slightly silky beneath.

Astragalus. There are a great many different species of Astragalus in Bashahr but only a few of them are of use in deodar ecology. Owing to the large number of species and the confusion which has occurred in naming them, Astragalus formed a very difficult group to deal with, particularly as in the case of the arid zone tufted forms, the flowers which are so essential for recognition of this genus were very seldom to be found at the time of my infrequent visits to the outlying areas along the Tibetan border. With the object of establishing the exact relationship with the true Tibetan flora, however, I give below all the data available about the Kanawar forms.

(a) Astragalus:- tall shrub types.

A. chlorostachys, Lindl. is very common in moist deodar forest as a companion with Thalictrum neurocarpum, Ainsliaea aptera, Adiantum fern and other plants related to the cooler sides of ravines, in which deodar persists and shows fine height growth over/

over a very profuse and rank growth of ground plants. On slightly drier ground, which is still capable of growing excellent deodar, it is often found with Indigofera and Thalictrum minus, and again there is a more closely localised association at the top of the deodar belt in the Bhabba and in Taranda range where A. chlorostachys occurs with Strobilanthes alatus and Bupleurum Candollii, just where the older spruce is often being replaced by a younger deodar crop.

A. chlorostachys persists with patches of moister deodar right into the arid zone but throughout Chini range it is very strictly confined to good deodar ground in the larger side-valleys. This is also the case in the Baspa where it occurs amongst heavy weed growth, in which Nepeta leucophylla and Salvia glutinosa are prominent.

A. graveolens, Buch-Ham. occurs sporadically in arid forest types such as neoza-deodar with Artemisia maritima and Lonicera hypoleuca as a straggly bush, and its moisture requirements seem to be exceedingly small.

occurs

A. coluteocarpus, Boiss. occasionally as a hollow-stemmed luxuriant bush along the edge of streams in the arid zone such as the Rong Gad, near the junction of the Tidong and the Suttlej, and is an indication of improved conditions on reaching the top of the pure neoza belt, with a prospect of blue pine and deodar coming in in that immediate neighbourhood.

(b) Astragalus:- close turf types.

The stemless or very short-stemmed species of Astragalus are frequent in the leguminous turf which is very characteristic of the dry zone deodar and blue pine forests and which shows its best development at about 10,000 feet where the deodar so often stops abruptly and the blue pine comes in above it. This turf varies considerably in its component species locally, but as a rule the major items are Astragalus strobiliferus, Royle, A. Candolleanus, Royle, (Royleanus, Bunge), A. rhizanthus, Royle, and A. peduncularis, Royle, along with Oxytropis mollis, Thymus Serphyllum, Lespedeza floribunda, Lotus corniculatus and Trigonella Emodi. This turf is a well developed feature from Urni and Kilba onwards up to Dubling, but most noticeable in the Barang, Purbani/

Purbani and Chini forests. It most certainly helps to conserve the scanty moisture but forms so dense a turf that deodar and blue pine regeneration must be interfered with to a certain extent.

(c) Astragalus:- thorny cushion types.

The low cushion scrub which is such a feature of the arid zone is found first as a purely alpine formation in Chini and Kailas along the upper limit of the dry zone blue pine, but with increased aridity it descends towards the valley until in the arid zone the forests disappear and the alpine formations abut directly upon the lower level Artemisia-Ephedra types of the valley bottom. Of these the commonest are A. polyacanthus, Royle and A. leptocentrus, Bunge. with A. strobiliferus, Royle less frequent, and A. Webbianus, Grah. only occurring towards Pu.

Parker includes A. oplites, Benth. for Kanawar, but so far as I could see this is indistinguishable from A. polyacanthus, Royle in its bushier form and from A. Webbianus, Grah. in its spinier form.

(d) Astragalus:- straggling scree bush types. A. cicerifolius, Royle, A. tibetanus, Benth., and A. anomalus, Bunge. are the chief species met with as straggling bushes on gravel scree and hot sandy alluvial banks in the dry and arid zones - e.g. round Bassering towards the upper reaches of the Baspa, and along the Tidong and Teti streams. They verge in places into the thorny cushion type already discussed but as a rule can be classed separately.

Colutea nepalensis, Sims. (C. arborescens, Linn.) is common between Jangi and Rarang on the hot south exposures of the Chini side from 6,000 - 8,000 ft. It is usually confined to the hottest bare slopes of the Suttlej valley where it grows in straggling gregarious clumps lower than the neoza-Roylea calycina - Lonicera hypoleuca formation and in the neighbourhood of Artemisia maritima. Occasionally it is found growing with stunted deodar in the further arid zone.

Oxytropis mollis, Royle. and Cicer soon-garicum, Steph. are both common components of the dry deodar-blue pine leguminous turf discussed under Astragalus (b) above.

Lespedeza/

Lespedeza. Several of the Lespedezas are so widely distributed and so difficult to distinguish in the field that they can be treated as one group for ecological purposes. L. sericea, Benth., L. juncea, Pers., L. Gerardiana, Grah. and to a less extent L. floribunda, Bunge and L. dubia, Schindler are found at all elevations up to 10,000 feet in several different associations of grassy forest undergrowth and hot open pasture grounds. In one such association developed on the hot slopes of the Pandrabis Suttlej and Bhabba at 7,500 to 9,000 ft. Lespedeza sericea is mixed with Anaphalis araneosa, Salvia lanata and Androsace rotundifolia, and further up the valley in Kailas and Chini Lespedeza floribunda often occurs with Dianthus angulatus under neoza or a neoza-deodar mixture, and both of these are fairly frequent components of the leguminous turf so common at about 10,000 ft.

The Lespedeza group as a whole has not much significance, except to indicate that where it penetrates uphill into deodar ground it probably marks a deficiency of moisture and difficulties in deodar regeneration work.

Desmodium. The various species are very widely distributed throughout Bashahr and their botanical forms are often difficult to distinguish specifically, but owing to their constant occurrence in most types of forest it is desirable to analyse them closely.

Desmodium tilliaefolium, G. Don is a constant companion of Indigofera Gerardiana in good deodar areas throughout the moist and most of the dry zones under fairly heavy canopies, and in such places the leaves are practically glabrous. The species is, however, much more adaptable than Indigofera, and varieties of every conceivable grade from glabrous to densely pubescent are found growing with very different companions. The most pubescent form is hardly distinguishable from D. nutans, Wall. of the hot open slopes below the chil pine belt.

Amongst forest officers it has been accepted that Desmodium is a good deodar indicator, but actually it is so widespread and adaptable that by itself it indicates nothing. In its most glabrous form D. tilliaefolium is a close companion of Indigofera, and these two together with Ainsliaea, Fragaria

Fragaria, Thalictrum, and Viola undoubtedly indicate good deodar conditions. Even under the best deodar stands, however, the Desmodium flourishes best under a very thin canopy, and this same glabrous form continues in company with other species such as Salvia glutinosa, Spiraea Lindleyana, Artemisia vestita, and A. vulgaris on open ground devoid of forest, and also persists along with bracken fern, Prinsepia utilis, Anaphalis araneosa, and Potentilla nepalensis, under pure blue pine. In fact this Desmodium is such a constant companion of the moister zone blue pine that it could more properly be called a blue pine indicator than a deodar one.

Desmodium nutans, Wall. as explained above, is practically indistinguishable from D. tiliaefolium in its strongly pubescent form, and it is referred to D. tiliaefolium in "Index Kewensis", but ecologically it is such an extreme form that it is better separated. It is very widely distributed in the hotter parts of the Sittlej valley in the moist zone along with chil pine, Rhus Cotinus, and Mallotus, and to a less extent in Kilba and the dry zone with Plectranthus, Salvia Moorcroftiana, neoza and Quercus Ilex.

Desmodium podocarpum DC., oxyphyllum DC., sambuense, DC. (floribundum, G. Don) and concinnum, DC. occur irregularly in the open and under chil pine and the lower parts of the deodar belt in the moist zone (e.g. Nogli Gad).

Erythrina glabrescens, Parker occurs only in the riverside association of Sterculia, Woodfordia, and Mallotus at about 4,000 feet near Jakri and below the chil pine belt.

Rhyncosia pseudocajan, Camb. is fairly common along the lower limit of the chil pine associated with Desmodium nutans, Pistachia, and Woodfordia. It is occasionally found above this level up to 8,000 feet but in such cases it is usually in grassy blanks and not under a forest canopy.

Rhyncosia himalensis, Benth. and sericea, Span. are occasionally met with as trailing shrubs under chil canopy, and in the sunny open spaces of the lower chil belt.

Flemingia strobilifera, R.Br. (fruticulosa, Wall.) occurs irregularly in grassy blanks in the chil and chil-Quercus incana forests of the moist zone.

Dalbergia/

Dalbergia Sissoo, Roxb. is found growing gregariously as a small tree in the more sheltered parts of the main valley bottom up to Jakri. It apparently requires shelter from the furnace blast of the hot wind which blows down the Suttlej gorge in summer, and it also needs an assured supply of moisture in the subsoil though not necessarily near the surface. It occurs in large patches along the bottom of the chil belt, but under better conditions than the common Mallotus-Plectranthus scrub.

Sophora mollis, Grah. occurs in gregarious clumps in the hot valley grazing grounds in the middle dry zone, - e.g. from Panwi Gad to Kilba, in the company of Artemisia-Plectranthus-Salvia and is best developed at Chagaon where Artemisia maritima becomes much commoner and where the chil pine is replaced by neoza.

Vicia. Several Vicias, notably V. rigidula^{g d}, Royle and V. tenera, Grah. occur sporadically as field weeds and also in several forest formations throughout the moist and dry zones. Up to 10,000 feet V. rigidula often appears in the leguminous turf and V. tenera in hedges of the deodar-blue pine belt, but the genus as a whole is so erratic in its distribution that it is of little value as an indicator.

Lathyrus. This genus, like Vicia, is very irregularly distributed, but is more closely allied with the hot valley grazing grounds and as a field weed, L. sphaericus, Retz. and L. pratensis, Linn. being the commonest species.

Vigna capensis, Walp. is occasionally found on hot grassy banks up to 8,000 feet - e.g. Panwi Gad - in company with Plectranthus, and Salvia Moorcroftiana.

Caesalpinia sepiaria, Roxb. is a prominent feature of the hotter Pandrabis glens below 6,000 feet, forming pure dense patches of scrambling bushes with long yellow flower sprays in the lower chil belt and in the neighbourhood of Deutzia staminea, Rhus cotinus and Colebrookia.

Bauhinia variegata, Linn. occurs in the valley bottom near Jakri in open pure stands as a small tree. It is very heavily lopped for fodder, which/

which probably accounts for its restricted distribution. Its pure groups are found on the more sheltered slopes in the neighbourhood of Cedrela Toona, Albizzia Julibrissin, and Dalbergia Sissoo, and between the chil pine belt above & the Mallotus-Plectranthus-Buddleia scrub below.

Albizzia Julibrissin, Durazz. is found occasionally along the riverside about Jakri as a large tree, usually in the company of Cedrela Toona on the moister slopes which are sheltered from the hot down-valley wind.

ROSACEAE/

ROSACEAE.

Prunus Jacquemontii, Hk. and prostrata Labill. are restricted to the dry and arid zones, where they are fairly frequent members of open shrub formations on hot, dry, rocky ground along with Rosa Webbiana, Ribes orientale, and Lonicera hypo-leuca, penetrating occasionally with them into open deodar and high-level blue pine forest, and becoming suppressed under any continuous canopy. In the arid zone they are also found in open neoza forest.

Prunus cerasoides, D. Don (Puddum, Roxb), P. persica, Stokes and P. armeniaca, Linn. are all cultivated as fruit trees by the hill people, and are occasionally found as escapes in undergrowth of deodar-blue/pine and broad-leaved forests of the deodar zone - e.g. P. persica is quite common in the deodar near Kilba, and in the lower Baspa.

Prunus cornuta, Wall (Padus, Linn) is a prominent member of the mixed broad-leaved formations of the Pandrabis thach type.

Prinsepia utilis, Royle is a very common shrub throughout the chil and deodar zones of the Simla and Kangra outer hills, and in Taranda and the moist zone up to Nichar it is quite a feature of the lower half of the deodar belt and the upper edge of the chil-ban oak forest. For a few miles beyond Nichar it occurs occasionally in the hotter types of deodar-chil and again in the deodar-neoza, but it is practically conterminous with the limit of the chil pine in the upper Suttlej.

Rubus. This genus is very widely distributed throughout the forests and scrubby grass-lands of the moist outer hills, but is less common in the dry zone. The moist zone species are difficult to separate ecologically as their habitats overlap and they are frequently mixed. R. paniculatus, Sm. R. ellipticus, Sm. and R. lasiocarpus, Sm. (including R. foliolosus, Don) are all common in the outer hills upwards from 4,000 ft., often growing together, but usually R. paniculatus frequents moist ravines and under ban oak-Rhododendron in the chil belt, R. ellipticus is more typical of an open canopy, and R. lasiocarpus of the top of the chil belt and the damper deodar-spruce forest under a much denser canopy/

canopy than either of these other two.

Rubus biflorus, Buch.-Ham. is also typical of the moister forests but is more closely associated with open deodar-blue pine. It is extremely common in the large burnt areas in Pandrabis in which fine deodar and blue pine pole crops were destroyed by the incendiary fires of 1921, and is a distinct feature of the recolonising process which is slowly taking place. The seral stages appear to be Valeriana and Anaphalis leading to Rubus biflorus and bracken, and later to blue pine seedlings.

Rubus niveus, Wall. is very variable both morphologically and ecologically. It occurs commonly in the outer hills with the first three species mentioned above and is frequently very difficult to distinguish from R. lasiocarpus. It frequents the same moist ravines in the deodar-spruce belt, but it also extends much further into the dry zone, being a common associate of Rhamnus virgata and Lonicera quinquelocularis in average deodar stands of Kilba and the middle dry zone.

Rubus purpureus, Bunge. (parvifolius, Linn.) is more definitely a dry zone species and it occurs throughout the dry zone in the upper part of the deodar belt and in the silver fir and blue pine forests above the deodar. Under fairly dense shade it becomes dwarfed and more of a creeping shrub, but in the openings caused by heavy fellings or fires it forms a rampant bush which interferes with deodar regeneration - e.g. Barang 37f in which fire followed a "seeding felling" and destroyed most of the remaining crop of deodar.

Spiraea Lindleyana, Wall. (sorbifolia, Linn.) is one of the commonest shrubs in Bashahr and is very widely distributed in several different associations. It is typical of the heavy shrub growth of practically all kinds of valley bottoms and reentrants unsuited to deodar and the other conifers, and in such places it is found, in the moist zone with Arundinaria, Deutzia, Rubus, and Viburnum, and in the dry zone with Rosa Webbiana, Viburnum, Salix denticulata, Impatiens spp, Polygonum polystachyum and Euonymus lacerus. It is also a prominent factor in the reclothing of earth slips and rock avalanches even in places obviously devoid of soil moisture; in such places it occurs with Salvia glutinosa, Viburnum, Plectranthus, and Artemisia maritima.

Spiraea/

Spiraea bella, Sims. is found as scattered bushes in the spruce-deodar forest, and it appears to be typical of the slightly drier slopes where the spruce is liable to give place to blue pine and deodar. It is usually associated with Ribes rubrum, Adiantum fern, Strobilanthes, Bupleurum Candollii and Potentilla nepalensis.

Spiraea canescens, D. Don is very widely distributed throughout the chil and lower deodar belts in both the outer hills and the middle dry zone, and it appears erratically in several different ecological groups but is never found in any great quantity.

Spiraea vestita, Wall and S. Aruncus, Linn. appear as herbs with perennial root-stocks in fairly moist forest types at 7,000 - 10,000 feet, e.g. with Spiraea bella, Ribes rubrum, and Valeriana Hardwickii under spruce-deodar, and again in the dry zone along water channels with Strobilanthes, Anemone rivularis, Pedicularis, and Impatiens.

Potentilla. This genus is very widely distributed and many of its species occur, but ecologically all species met with fall into one or two groups, viz:-

(a) Moist subalpine meadows type:- P. nepalensis, Hk. and P. argyrophylla, Wall. are the commonest. In the open blue pine stands of Pandrabis and Taranda they occur constantly along with Geum urbanum, Rosa sericea, Thermopsis barbata, Polygonum molle, Fragaria, and Leontopodium. Further up the valley in the middle dry and even in the arid zone they occur occasionally in the neighbourhood of water channels and in well watered lush meadows in company with Anemone rivularis and Geranium Wallichianum.

P. fragarioides, Linn. belongs to the moist meadow type, but is more or less confined to meadows and grazing lands in the chil pine belt - e.g. Chota Kamba in Pandrabis.

(b) Arid Zone Scrub. In this group Potentillas are one of the commonest components, coming in as ordinary dry alpine pasture plants above the forests in Kailas and Chini ranges and developing into the cushion-scrub type as the arid zone is reached.

P. rigida,/

P. rigida, Wall. and eriocarpa, Wall. are the first met with (Hiranghati, 12,000 feet, at the Sotlej and Baspa junction), but the most common ones towards the Tibetan border are:- P. biflora, Willd. P. argyrophylla var. leucochroa, Wall. and P. ambigua, Camb. There is a marked development of this type of dense low bushy scrub in the Nisang Gad beyond the Tidong river.

Geum urbanum, Linn. and elatum, Wall. are both frequent companions of the moist subalpine meadow type of Potentilla and occur under blue pine stands in the moist zone. They also penetrate far into the dry zone in Kilba and Chini wherever better quality blue pine and deodar occur in the neighbourhood of open pasture lands.

Fragaria vesca, Linn. is a constant item in several forest formations and is so ubiquitous that by itself it is of little value as an indicator. When considered in conjunction with its companions, however, it is valuable. Along with Viola spp. and Thalictrum minus and under Indigofera and Desmodium it indicates good deodar ground, but along with Adiantum fern, Anemone rivularis, Ainsliea, and Strobilanthes, it indicates conditions too damp for pure deodar and typical of spruce-deodar mixtures.

Along with Leontopodium alpinum it occurs under pure blue pine at Chagaon above Wangtu, and with the common alpine herbs it accompanies deodar and blue pine far into the dry zone. Its constant occurrence on the freshly broken soil of slips and snowslides shows it to be a valuable coloniser along with bracken and Spiraea Lindleyana. It is also found in the higher fir forests mixed with Nepeta spp., Pedicularis spp., and Halenia elliptica, and with/association extends above the forest into the alpine meadows.

Rosa. The three common bush roses, R. macrophylla, Lindl., R. sericea, Lindl. and R. Webbiana, Wall. all have certain characteristics in common. They are all better developed under an open canopy than under a dense one, and they all tend to lose their thorns when growing under forest shade of any depth. Their geographical zones are not strictly defined and they overlap considerably, but roughly speaking they occur as follows:-

R. macrophylla/

R. macrophylla is found chiefly with Cotoneaster bacillaris, Arundinaria, and Acer in the moist forest undergrowth of the upper deodar-spruce belt in the wetter parts of Taranda and Pandrabis, although it penetrates far into the dry zone in damper reentrants in deodar forest (Boktu 80b).

R. sericea occurs throughout the middle dry zone in average deodar along with Lonicera, Abelia and Rhamnus virgata on hotter aspects and with Thalictrum, Nepeta leucophylla, and Rubus on damper or colder situations. It is also common in blue pine forest in Kilba and the Bhabba along with Potentilla, Geum, Morina, and bracken.

R. Webbiana is typical of the inner dry and arid zones, occurring under dry deodar or blue pine along with Ribes orientale, Prunus Jacquemontii and at lower levels along with Colutea, Ephedra, and Artemisia.

Rosa moschata, Herrm. is a climber found frequently in the chil and lower deodar belts of the moist zone, and in open scrub and hedgerows in this neighbourhood.

Pyrus baccata, Linn. is cultivated in the dry and arid zone villages and occurs occasionally in moister types of forest vegetation, but is nowhere common.

Pyrus Pashia, Buch.-Ham. is common throughout the moist zone of Taranda and lower Pandrabis, frequenting warm sheltered ravines along with Pieris, Ulmus, and Populus in the ban oak-Rhododendron type and in similar situations at higher levels, in the typical broad-leaved thach.

Pyrus lanata, D. Don and less commonly, P. foliolosa, Wall. and P. Aucuparia, Ehrh. occur along with or in place of Pyrus Pashia in broadleaved thach associations, but they are confined more to the upper half of this type. An interesting development is a half-acre of pure Pyrus lanata with Chaerophyllum reflexum as undergrowth in a warm sheltered hollow in spruce forest at 9,100 ft. in Ganwi Gad. P. foliolosa also runs up into the alpine belt above the conifers in the moist zone, mixing with birch and the dwarf Rhododendrons, while P. Aucuparia does the same thing in the drier conditions of Kilba and Kailas.

Cotoneaster/

Cotoneaster bacillaris, Wall. is very widely distributed throughout the moist zone and to a less extent in the dry zone. It is heavily browsed by goats and sheep and wherever it is subject to browsing it alters entirely in appearance from a handsome tall shrub to a miserable small-leaved cushion-bush.

It occurs commonly in moist blue pine and spruce forest with Rosa macrophylla, Arundinaria, and Prunus cornuta, and again under horse-chestnut and other broad-leaved canopies with Ilex dipyrrena and Deutzia, then again under deodar and ban oak with Desmodium, Berberis, and Lonicera. Towards the dry zone it is restricted to fairly moist associations, occurring with Indigofera and Desmodium under good deodar as far up as Rarang beyond Chini, and with Hippophae rhamnoides forming open scrub in the high level blue pine of the Baspa.

Cotoneaster acuminata, Lindl. is definitely restricted to the moist zone and is found occasionally in Pandrabis in similar places to C. bacillaris.

C. rosea, Edgew. and C. obovata, Wall. are more typical of the middle dry zone, obovata being found under good deodar in Boktu Compartment 80b.

Cotoneaster microphylla, Wall. is the commonest plant of the dry alpine zone and forms a connecting link between the lush meadows of the moister alpine pastures and the cushion-bush forms of the Tibetan arid highlands. The varieties buxifolia and thymifolia enumerated by Parker appear to be entirely governed by the intensity of browsing and are hardly valid as distinct varieties. It comes in first in the neighbourhood of the Cynoglossum-Morina-bracken ground flora of the high level blue pine of Chini and Kailas and develops more strongly when mixed with Caragana Gerardiana, Juniperus, Verbascum, and Berberis. Near Shiasu it occurs as a purely cushion-bush type in ravines subject to snow-slides.

Cotoneaster nummularia, Fisch. is similar to C. microphylla in its requirements but is confined more strictly to the further arid zone.

SAXIFRAGACEAE.

SAXIFRAGACEAE.

Astilbe rivularis, Buch - Ham, is an infrequent member of the ground flora in the deodar belt in the moist zone, occurring up to Nichar along with Spiraea bella, Ribes rubrum, and Wulfenia Amherstiana under damp spruce-deodar.

Saxifraga ligulata, Wall. (ciliata, Royle) is a common rock plant of the moist zone deodar and spruce forests, well developed in the Nogli Gad and denoting plentiful subsoil moisture draining through the rock fissures. It persists into the dry zone under deodar and blue pine.

Saxifraga Stracheyi, Hk. is similar in habit to S. ciliata, but is much less dependent on surface moisture. It is common on sheet rock surfaces and rocky avalanche scree throughout the arid zone up to Nisang, but it appears to have little affinity for any type of forest, except as a coloniser on rock outcrops.

Parnassia nubicola, Wall., occurs occasionally in the damper types of alpine meadow along with Nepeta leucophylla, Craniotome versicolor and Spiranthes australis.

Deutzia corymbosa, R.Br. (parvifolia, Bunge) is a common member of the moist ravine associations in which Arundinaria, and Acer spp. are prominent in Pandrabis at 8,000-9,000 feet. It also persists well into the dry zone in the broadleaved scrub of ravines in the deodar belt.

Deutzia staminea, R.Br. comes in considerably lower than D. corymbosa and is frequent in the less shaded ravine scrub of the chil zone at 4,000-6,000 feet, along with Caesalpinia sepiaria and Buddleia paniculata, and higher up in the broadleaved thach type. It is also found irregularly in the moister blue pine deodar forest but is here much smaller.

Philadelphus tomentosus, Wall. (coronarius Linn.) is somewhat similar to the Deutzias and replaces them in the middle dry zone, occurring in reentrants in moister deodar forest in Chini (Boktu 80b) along with Lilium polyphyllum, Astragalus chlorostachys/

chlorostachys and Thalictrum reniforme, but only in very restricted areas.

Ribes rubrum, Linn. and less commonly R. glaciale, Wall, are found in the moist zone with a variety of associates, but more or less confined to damp forest with a complete canopy, e.g. Taranda spruce-deodar forest with Ainsliaea aptera and Thalictrum reniforme.

Ribes Grossularia, Linn. is more associated with the middle dry zone but in conjunction with other plants which require a modicum of moisture, e.g. with Lotus corniculatus, Gentiana argentea, saxifrage and strawberry under deodar stands in Kailas range.

Ribes orientale, Desf. is an extremely arid type associating with Caragana Gerardiana and Cotoneaster microphylla in the subalpine and alpine grazing grounds and open blue pine forests of the arid zone.

HAMAMELIDACEAE.

Parrotia Jacquemontiana, Decne. has a curious distribution in Bashahr, as it occurs scattered in the warmer scrub jungle of the Baspa valley bottom along with Acer pentaphyllum, Viburnum, Lonicera, and Abelia, in an association which hardly penetrates into the lower deodar belt above it. This is an entirely different ecological role from that played by Parrotia in the Murree hills, where it forms a dense hazel-like undergrowth, gregarious to the exclusion of all other species of shrub and on colder and moister sites than this Bashahr growth type. Outside the Baspa it occurs sporadically in the middle dry zone of Chini and Kailas, but is not common.

CRASSULACEAE.

Sedum rosulatum, Edgew. adenotrichum, Wall. and multicaule, Wall. are all fairly frequent on damp/

damp rock outcrops and also in damp turf of spruce and deodar forests along with Adiantum and other ferns.

Sedum Ewersii, Ledeb. is more widely distributed than the other Sedums and is found in damp turf and damp rock crevices throughout the dry and arid zones from Pandrabis to the Tibetan border.

Sempervivum acuminatum, Jacquem. often occurs along with Sedum Ewersii and with it penetrates to the Tibetan border. (Dubling 11,000 feet).

MYRTACEAE.

Eucalyptus Globulus, Labill. occurs in Sholtu garden, where it serves a useful purpose as a slight cover for the grape vines. This is at 5,000 feet and above this it suffers badly like other Eucaplypts from snow-break.

MELASTOMACEAE.

Osbeckia stellata, Wall. occurs in the chil belt, e.g. in Nogli Gad below 6,000 feet along with Berberis, Buddleia, and Caryopteris Wallichiana.

LYTHRACEAE.

Punica Granatum, Linn. occurs in the hot Suttlej bottom in the outer hills and a few trees occur up to Jakri, but not beyond.

Woodfordia floribunda, Salisb. is common in the chil pine belt and the hot scrub jungle at the bottom of the chil, along with Bauhinia, Pistacia, Desmodium nutans, and Rhyncosia.

ONAGRACEAE.

ONAGRACEAE.

Epilobium. Several Epilobiums are common in the grass-lands of the outer hills, but only E. parviflorum, Schreb. has been found penetrating to the dry zone (Boktu 10,000 feet).

CUCURBITACEAE.

Herpetospermum caudigerum, Wall. occurs occasionally as a climber in wet ravines and meadow hedges, e.g. Baue in Bhabba Valley at 7,500 feet along with Polygonum spp. and Impatiens spp.

BEGONIACEAE.

Begonia picta, occurs on damp rocks in the outer hills and in the Bashahr moist zone (Nogli Gad, 7000 feet).

DATISCEAE.

Datisca cannabina, Linn. is found infrequently in the hot grass-lands of the Suttlej gorge in Taranda range along with Desmodium nutans and Buddleia paniculata.

UMBELLIFERAE.

Coriandrum sativum, Linn. occurs quite frequently in the neighbourhood of water channels in the dry zone as an escape from field crops - e.g. under deodar at Barang with Anemone rivularis and Geranium Wallichianum.

Bupleurum. These are very widely distributed but some species are found locally in quite prescribed areas, and are useful ecologically.

B.lanceolatum/

B. lanceolatum, Wall. and Candollii, Wall. are both frequent under dry zone deodar, e.g. along with Erysimum, Stellaria, and Selinum under neoza-deodar canopy in Kilba and with Polygonum and Thalictrum, under pure deodar and spruce-deodar mixtures. Both of them disappear rapidly from exposed ground in the forest zone.

Bupleurum falcatum, Linn. on the other hand is almost ubiquitous, being typically a plant of forest shade but surviving also on very hot slopes and inferior soils. It also extends much further into the arid zone and occurs at Dubling along with Hyssopus, Rubia, and several Compositae in the last bit of deodar-blue pine forest.

Bupleurum tenue, Buch - Ham. forms an item in some varieties of the leguminous turf of dry zone blue pine, occurring near Pangl along with Lotus, Trigonella, Astragalus Candolleanus, Oxytropis mollis and Nepeta supina.

Bupleurum Maddeni, Clarke is more in the nature of a field weed than the foregoing species. It is common as a weed in Chini orchards.

Pimpinella diversifolia, DC. is very common throughout the whole valley on the hot open slopes immediately above the river and on the lower grasslands of the southern exposure along with such plants as Anaphalis spp., Nepeta linearis, Androsace rotundifolia and Rhus Cotinus.

Anthriscus nemorosa, Spreng. and Carum Carvi Linn. are both fairly common under dry and arid zone deodar.

Pleurospermum Brunonis, Benth. appears to take over the rôle of Pimpinella at higher elevations, occurring occasionally amongst Cotoneaster microphylla and Juniperus communis, and also in herbaceous meadows.

Chaerophyllum villosum, Wall. and reflexum, Lindl. both occur in the moist zone under spruce and the higher blue pine and in broadleaved forest, the reflexum being more definitely an indicator of a damp top soil.

Selinum vaginatum, Clarke has been noticed along with Bupleurum, Erysimum, and Stellaria under deodar/

deodar-neoza canopies in Kilba.

Angelica glauca, Edgew, is fairly widely distributed amongst alpine and subalpine meadow types and also occurs in the moister spruce-deodar along with Indigofera, Astragalus chlorostachys, and Thalictrum neurocarpum and under high level blue pine along with Pedicularis spp.

Heracleum canescens, Lindl. and candidans, Wall. are common and often gregarious on many different types of the damper forest floors, and also along water channels in the dry and arid zone. They may be taken as an indication of the presence of soil moisture.

ARALIACEAE.

Aralia cachemirica, Decne, occurs occasionally in the moister spruce forests on ground obviously too damp for deodar, along with Valeriana Hardwickii, Trillium and Polygonatum.

Hedera Helix, Linn. is a common climber in the forests of the outer hills at all elevations up to 10,000 feet, but in the Sutlej valley it penetrates only up to the Bhabba valley and is usually confined to broadleaved ravines and the damper spruce-deodar forests of Taranda and lower Pandrabis, sometimes mingling in the forest canopy by climbing up the largest spruce trees.

Cornus macrophylla, Wall. is a common tree in the mixtures of broad-leaved species so typical of the Pandrabis thach along with Pyrus, Pieris, and Corylus. Beyond this it occurs infrequently in shady places in Kilba and the upper valley, one large tree growing in a recess in the cliffs of the Sutlej Gorge near Shongtong.

Cornus oblonga, Wall. and capitata Wall. occur along with C. macrophylla but neither are so common or so conspicuous.

CAPRIFOLIACEAE.

Viburnum/

ubiquitous as

Viburnum cotinifolium, D. Don is almost as Spiraea Lindleyana and has a similar distribution, being commonest in the open sunny scrub jungle of stream beds and scree hollows, but also occurring under forest canopies of many different types. It penetrates far into the dry zone, being found along with S. Lindleyana at Dubling, but in the upper dry zone it is much less common than the Spiraea is. These are so frequently found on screes and avalanche sites that they may be taken to indicate unstable ground, particularly if they are accompanied by other rapid colonisers such as Tragopogon, Senecio, Leptorhabdos, Impatiens brachycentra, Chenopodium opulifolium and bracken (Pteris aquilina).

Viburnum nervosum, D. Don and less commonly V. stellulatum, Wall. are typical of moist forest undergrowth in the outer hills, but neither of them are found much outside the spruce-deodar and Kharsu oak-silver fir belts of the Suttlej moist zone, and the damper side valleys such as Nogli and Ganwi Gads.

Abelia triflora, R. Br. is very widely distributed. In the moist zone of Taranda and Pandrabis it is definitely an indication of dry conditions, and is commonest under the open canopy of drier deodar along with Lonicera angustifolia and Prinsepia utilis. In the middle dry zone of the Bhabba and Kilba it is generally an indication of satisfactory conditions for deodar growth but points to difficulties in regeneration work, occurring as it does with Rhamnus virgata, Jasminum humile, Rosa sericea, Berberis spp., and Rubus niveus. This also holds for the Baspa where it grows with these species and also with Indigofera and Desmodium which show dry zone modifications of growth.

Lonicera. This is a very widely distributed genus with much variety in ecological types, some of the species being of undoubted value as indicators.

Lonicera quinquelocularis, Hardw. and angustifolia, Wall. are probably the commonest bushes of both moist and middle dry zones, occupying chiefly the warm dry sunny glades along the lower level of the deodar belt in both the chil pine and neoza pine areas and less frequently extending uphill to 9,000 feet. In the moist zone they are generally mixed with Desmodium tiliaefolium, Coton-easter bacillaris, Ilex dipyrena, Berberis Lycium, Deutzia/



ALPINE PASTURES ABOVE FOREST.

- (51) Piri Peak, 14,000 feet, showing steep screes of Sutlej face and alpine pasture lands on further side away from river gorge.
- (52) Morina Coulteriana socies in alpine grass-lands.



Rubia cordifolia, Linn. is frequently found in grass-lands and in the warmer types of deodar forest throughout the valley up to Dubling, but it is very erratic in its choice of associates.

Galium. Several Galiums are found in the warm grass-lands and forest turf types throughout the valley. Galium Mollugo, Linn. is fairly common in the dry Astragalus-Thymus turf of the Chini and Kailas forests, but it also occurs in several other associations. Galium Aparine, Linn. is more typical of damp ravines.

VALERIANACEAE.

Valeriana Wallichii, DC. is extremely common throughout the moist zone under deodar, blue pine and spruce, and is so widely met with in all varieties of conifer forest formations that it indicates only a certain amount of shade.

Valeriana Hardwickii, Wall. is restricted to much damper ground than V. Wallichii and is fairly regular in its distribution over the damper hollows of the moist zone spruce-deodar along with Trillium, Polygonatum, and Strobilanthes.

DIPSACEAE.

Morina persica, Linn. and longifolia, Wall. are both common in the damper blue pine forests above 10,000 feet in Pandrabis in the neighbourhood of Potentilla, Geum, bracken, and Heracleum.

Morina Coulteriana, Royle is more characteristic of the open alpine pasture lands above the tree limit, and on exposures avoided by blue pine and fir forest. In such places it grows along with Caragana Gerardiana, Juniperus communis, Cynoglossum Wallichii, and Veronica biloba (Urni 11,000 feet) and Rhododendron campanulatum, Potentilla rigida, and Polygonum vacciniifolium (Hiranghati 12,000 ft.) M. longifolia also occurs occasionally in these alpine pasture associations as well as under blue pine canopy.

Dipsacus/

Dipsacus strictus, D. Don occurs fairly frequently in damp pasture lands throughout the moist and dry zones, e.g. in mixture with Cannabis, Boenninghausenia, Hedychium, and Corydalis, in the open spaces of Panwi spruce-deodar belt and again with Origanum, Pimpinella, and Parnassia in grassy meadows near the Baspa river.

COMPOSITAE.

Artemisia maritima, Linn. is the commonest plant of the upper valley. It replaces Plectranthus rugosus as the chief plant of the hot slopes below the forest belt about Wangtu, and continues to increase until towards the Tibetan border it is the only plant over very large areas of the arid zone, entirely taking the place which grass holds in the grass-lands of the outer hills. In the middle dry zone of deodar A. maritima occurs pure on the lower valley slopes with southern exposure, and on cooler aspects it occurs in the lower forest belt mixed with Plectranthus in open places, and along with Abelia, Lonicera spp., Rhamnus virgata and other shrubs under the shade of open deodar and neoza stands.

Artemisia vulgaris, Linn. is a very widely distributed plant in the middle dry zone, and its function varies considerably. In the moist zone it occurs with Plectranthus on the hottest slopes immediately above the river below Nichar, but beyond Wangtu it occurs in a great variety of associations e.g. with Artemisia maritima and Lonicera hypoleuca, under dry neoza; with Artemisia vestita adjoining leguminous turf areas under deodar blue pine; and in Barang and Purbani it is quite frequent in good deodar areas. Its characteristics appear to alter with its geographical position, and in the further dry zone it serves as an indicator of relatively better conditions than in the moist monsoon area.

Artemisia vestita, Wall. is not so widely distributed as either of the above, and as a rule where it is found in mixture with either of them it points to improved conditions for tree growth. Some very glaucous varieties of A. vestita are found on hot sites with A. maritima, Plectranthus, Hieracium and/

and Picris, but the commoner type is that of the regular dry zone deodar of the best type, growing with Fragaria, Thymus, Thalictrum, Indigofera, and in drier places with Microglossa.

The rest of the Compositae are so numerous and so widely distributed that they can best be dealt with in tabular form to indicate roughly the ecological significance of those commonly met with.

DAMP/

DAMP FOREST TYPES.

Broad-Leaved Ravine:

Inula cuspidata, Clarke.
Senecio alatus, Wall.
 " *rufinervis* DC.

Spruce - damper deodar.

Ainsliaea aptera, DC.
Anaphalis triplinervis,
 Sims.
Carpesium cernuum, Linn.
Erigeron multiradiatus,
 Benth.
Lactuca Scariola, Linn.
Saussuria hypoleuca,
 Spreng.

Of the above, Ainsliaea is the most useful indicator of spruce ground in which a good percentage of deodar may be expected.

DRY FOREST TYPES.

Chil Pine:

Crepis japonica, Benth.
Inula Cappa, DC.

Deodar-neoza pine and
Deodar-blue pine.

Anaphalis nubigena, DC.
 " *Royleana*, DC.
Artemisia vestita, Wall.
 " *vulgaris*, Linn.
Aster altissimus, Wild.
Emilia sonchifolia, DC.
Gerbera lanuginosa, Sch.
Gnaphalium luteo-album,
 Linn.
Lactuca orientalis, Boiss.
Microglossa albescens,
 Clarke.
Senecio alatus, Wall.
 " *pedunculatus*,
 Edgew.
Pterotheca Falconeri, HK.
Tragopogon gracilis. D. Don.

Of the above, Microglossa is a constant companion of deodar under dry conditions.

High/

High Level blue pine.

Anaphalis cinnamomea, Clarke
Arctium Lappa, Linn.
Crepis sibirica, Linn.
Erigeron alpinus, Linn.
Leontopodium alpinum, Cass.
Senecio graciliflorus, D C.

Damp Meadow Type.

Bidens bipinnata, Linn.
Eupatorium cannabinum, Linn.
Myriactus Wallichii, Less.
Solidago Virgaurea, Linn.

Dry Grassland Type.

Anaphalis adnata, D C.
 " *araneosa*, D C.
Aster asperulus, Wall.
Cnicus Wallichii, Hk.
Conyza japonica, Less.
Echinops niveus, Wall.
Gnaphalium hypoleucum, D C.
Hieracium vulgatum, Fries.
Lactuca dissecta, D. Don.
 " *longifolia*, D C.
 " *macrorrhiza*, Hk.
Laggera alata, Sch.
Phagnalon niveum, Edgew.
Picris hieracioides, Linn.
Prenanthes Brunoniana, Wall.
Saussurea candidans, Clarke.
 " *obvallata*, Wall.
Senecio chrysanthemoides,
 D C.
S. nudicaulis, Buch - Ham.
Serratula pallida, D C.
Sonchus arvensis, Linn.
Tanacetum nubigenum, Wall.
Tragopogon gracilis, D. Don.
Artemisia maritima, Linn.
Aster mollisculus, Wall.
Emilia sonchifolia, D C.
Lactuca Lessertiana, Clarke.
Tanacetum senecionis, Gay.
Taraxacum officinale, Wigg.

Arid Scrub Type.

Artemisia maritima, Linn.
Aster mollisculus, Wall.
Emilia sonchifolia, D C.
Lactuca Lessertiana, Clarke.
Tanacetum senecionis, Gay.
Taraxacum officinale, Wigg.

CAMPANULACEAE.

Campanula latifolia, Linn. is fairly common in the damper blue pine and deodar forests of the Suttlej moist zone as an occasional member of the Potentilla-Geum-Fragaria-Thalictrum group.

Campanula colorata, Wall. is more often met with on cliffs in the moist zone than in forest, although it occurs on a great variety of sites.

C. canescens, Wall. is/

is found in field walls in the arid zone.

ERICACEAE

Cassiope fastigiata, D. Don is a plant of the drier alpine meadows above the tree level in Chini and Kilba, where it mixes with Saxifraga, Gentiana, Meconopsis, Potentilla etc.

Gaultheria trichophylla, Royle occurs in the middle dry zone along the upper tree limit along with Rhododendron campanulatum.

Pieris ovalifolia, D. Don is very regularly found throughout the moist zone wherever the Quercus incana-Rhododendron arboreum group appears in the chil pine belt of the main Suttlej valley in Taranda. It continues uphill with the other broad-leaved species of the thach forest, but is not so typical of this higher group.

RHODODENDRON.

Rhododendron arboreum, Sm. is a very prominent feature of the moist zone, covering large areas of the lower forest belt along with Quercus incana and less commonly Pieris ovalifolia and Pyrus Pashia, with undershrubs such as Arundinaria, Spiraea, Buddleia, and Deutzia. This formation occurs below 7000 ft. in the side valleys of Pandrabis, and also of Taranda but in the latter it is better developed on the northern exposure of the main Suttlej valley between 7000-8000 ft.

Rhododendron campanulatum, D. Don, Anthropogon, D. Don, and lepidotum, Wall. are all alpine plants occurring along the upper limit of the silver fir of the moist zone and the high level blue pine of the middle dry zone, though they are occasionally found as a dense gregarious scrub in ravines at lower levels, e.g. R. campanulatum at 9500 ft. in Shoang forest. R. lepidotum is more characteristic of the outer hills than the other two which are constantly found at over 12000 ft. in Chini and Kailas with Morina, Potentilla rigida and Polygonum vaciniifolium.

PRIMULACEAE

PRIMULA/

PRIMULA.

Primula petiolaris, Wall., denticulata, Sm. and rotundifolia, Wall. are all met with in the alpine and upper forest belts of the Sutlej. They vary in water requirements markedly, petiolaris being common in very damp ravines of the moister spruce forests and denticulata in drier parts of these forests, while both of them extend far into the dry zone as true alpiners. P. rotundifolia is confined entirely to the inner dry and arid alpine zone.

Primula floribunda, Wall. on the other hand is not an alpine as it is confined to damp rocks below 6,000 feet, e.g. on the cliffs of the Sutlej gorge at Wangtu.

ANDROSACE.

Androsace rotundifolia, Hardw., and lanuginosa, Wall. are both common in the hot dry lower grasslands of Pandrabis, occurring along with Salvia lanata, Nepeta linearis and Rumex hastatus in heavily grazed lands. Of the two rotundifolia frequents hotter and drier sites than lanuginosa.

Androsace sarmentosa, Wall. occurs irregularly on damper rocks and along water channels in the dry and arid zones.

MYRSINACEAE.

Myrsine africana, Linn. is only found occasionally in the chil pine belt and does not extend beyond the heavy monsoon zone of the outer hills.

STYRACEAE.

Symplocos crataegoides, Buch. - Ham. occurs occasionally in the chil and blue pine-deodar belts of the moist zone but is nowhere common.

OLEACEAE.

FRAXINUS.

Fraxinus micrantha, Lingelsh. occurs infrequently in the mixed broad-leaved forest of some of the damper Pandrabis valley bottoms along with Buxus, Ulmus laevigata, Alnus, and Acer spp. and an undergrowth of Adiantum, Polygonatum, Habenaria and ferns.

Fraxinus/

Fraxinus zanthoxyloides, Wall. is a frequent feature of the lower slopes of the inner valley. Beyond Wangtu it is mixed with Olea cuspidata, Zanthoxylum alatum and Pistacia, but these drop out after a few miles and in the Baspa and beyond it is mixed with Acer pentapomicum, Daphne oleoides, Plectranthus, and Artemisia maritima below the Quercus Ilex-neoza belt, and occasionally occurs higher in that belt and amongst the lowest dry deodar stands. Towards the arid zone, e.g. in the Tidong valley, the Fraxinus ceases to be a dominant tree in the open scrub forest and is found under the shelter of the scattered neoza and deodar trees as a rather reduced bush along with Lonicera hypoleuca, Artemisia maritima, Senecio and Nepeta linearis, but it persists in the Artemisia-Ephedra scrub as far as Kanam.

Jasminum humile, Linn. and less commonly J. officinale, Linn. occurs in several types of forest undergrowth, varying from the Litsea-Sarcococca-Skimmia type of the moist Pandrabis broad-leaved forests to the Plectranthus-Microglossa-Lonicera-Abelia type of the Chini and Kailas middle dry zone, but throughout showing a sort of vague affinity with good deodar conditions.

Syringa Emodi, Wall. occurs irregularly in forest shade in the dry zone deodar belt both under deodar and in the broad-leaved copses in moister reentrants - e.g. along with maples, Euonymus lacerus, Rhus, Asplenium Trychomanes, and Nephrodium Brunonianum.

Olea cuspidata, Wall. is one of the outer foothills species which persist in the hot dry Sutlej gorge for a few miles above Wangtu in company with Fraxinus zanthoxyloides and Pistacia, extending for a short distance beyond the inner extreme of the chil pine.

APOCYNACEAE.

Vallaris Heynei Spreng., and Trachelospermum fragrans, HK. are climbing shrubs of the outer ranges and in Bashahr are confined to damp ban oak-chil pine reentrants in Nogli Gad.

ASCLEPIADACEAE.

Periploca calophylla, Falc. is uncommon and occurs only in the bottom of warm shady ravines e.g. Panwi Gad at its junction with the Sutlej, along with/

with Salix tetrasperma and Cornus macrophylla, thus showing the survival of a warm monsoon climate near the point where Chil gives place to neoza pine.

CYNANCHUM.

Tylophora Govanii, Decne, and Cynanchum Roylei, Wight are both fairly common as members of dry zone low level open scrub formations - e.g. along with Senecio chrysanthemoides, Roylea calycina, Arenaria serpyllifolia and Saussurea candidans in the hot open grasslands of Wadang in the lower Baspa.

Cynanchum auriculatum, Royle and also C. Dalhousiae, Wight are more typical of dry deodar forest and rocky ground under partial shade - e.g. with Bupleurum lanceolatum, Stellaria cristata, and Selinum vaginatum in the Kilba lower deodar belt.

Cynanchum glaucum, Wall. is a moist zone plant typical of the damper spruce-deodar forests.

LOGANIAC/EAE.

Buddleia paniculata, Wall. is very common in hot dry places and is usually associated with Plectranthus and Mallotus below the chil pine belt, and with Spiraea Lindleyana, Rubus, Lonicera, etc. in the open scrub of ban oak and Rhododendron. Further up the Sutlej about Wangtu it is mixed with Debregeasia hypoleuca, Desmodium nutans, and Salvia Moorcroftiana and beyond this it occurs less commonly in the Artemisia-Daphne-Plectranthus belt of the middle dry zone.

GENTIANAC/EAE.

Gentiana quadrifaria, Blume. is typical of damper meadows and grassy turf in the neighbourhood of the spruce-deodar belt, and with Ranunculus in meadows.

Gentiana/



EROSION: EARLY STAGES.

- (53) Deodar and blue pine forest at Purbani destroyed by a fire and now deteriorating into shifting screes.
- (54) A landslip in Keuncha Gad forest, probably originated by heavy grazing.



Gentiana argentea, Royle and capitata, Buch.-Ham. have a similar habitat and are found mixed with Thymus in a type of turf, such as is often found under blue pine, but moister than either the Thymus-Leontopodium or Thymus-Astragalus-Oxytropis types.

Gentiana Kurroo, Royle and tianschanica, Rupr. var genuina are both frequent members of the dry zone alpine pastures along with Saxifraga, Meconopsis, and Cassiope.

Swertia purpurascens, Wall. and cordata, Wall. are both frequently met with in the damper spruce deodar of the outer ranges.

Halenia elliptica, D.Don. is also typical of the spruce-deodar forests and is a very regular feature of such forest wherever it occurs in the dry zone - e.g. Barang in Kailas and Boktu in Chini, along with Nepeta spp., Bupleurum tenue, Adiantum and Ainsliaea.

BORAGINACEAE.

Cynoglossum furcatum, Wall. is common on the outer hills in alpine and subalpine meadows, occurring with a considerable variety of associate plants.

Cynoglossum micranthum, Desf. and C. Wallichii, G.Don are more typical of the dry zone alpine pasture lands under high level blue pine and silver fir, along with Geranium Wallichii and G. Robertianum, Morina, and Veronica biloba, and again in the lower deodar - neoza belt in mixture with Roylea, Thymus, and Myosotis.

Onosma echioides, Linn. is a fairly common plant on arid zone screes and is also found under open blue pine and deodar in the open forests of the arid zone.

Mertensia racemosa, Benth. is fairly widely met with in several formations but is most typical of the blue pine forest of the moist zone, growing under open pine along with Thymus, Leontopodium, and Anaphalis cinnamomea, and also under/

under denser shade in spruce-blue pine and spruce-deodar along with Anaphalis triplinervis, Arisaema, Potentilla, Geum and Roscoea.

Myosotis cespitosa Sch. and sylvatica, Hoffm. are common in the dry scrub of the deodard-neoza belt along with Cynoglossum micranthum.

CONVOLVULACEAE.

Convolvulus arvensis, Linn. is a common creeper amongst field crops and is occasionally found in forest adjoining cultivation.

Cuscuta europaea, Linn. is common as a creeper in open scrub and amongst field crops, e.g. strawberry beds in Sholtu garden.

SOLANACEAE.

Solanum Dulcamara, Linn. and xanthocarpum, Schrad. are found as climbers in the moist zone forests, chiefly spruce-deodar and deodar-chil pine.

Withania coagulans, Dun. occurs only in the hot rocks of the Suttlej valley and like Capparis spinosa and Olea cuspidata, is a foothill species persisting under the dry heat conditions of the upper Suttlej gorge.

Atropa Belladonna, Linn. occurs in undergrowth in the deodar reentrants of the dry and arid zones, - e.g. Kashang Gad along with Indigofera, Desmodium, Cotoneaster bacillaris, Thalictrum and Polygonatum.

Datura Stramonium, Linn. is found on hot ground along the valley bottom along with Debregeasia, Desmodium nutans, and Rhus cotinus.

Hyoscyamus niger, Linn. occurs occasionally on waste ground near cultivation in the dry zone along with Salvia glutinosa and Leptorhabdos.

SCROPHULARIACEAE.

Verbascum/

Verbascum Thapsus, Linn. is a common feature of the dry zone, occurring on any exposed screes along with Silene Griffithii and S. inflata, and on more stable but very dry ridges along with Cargana brevispina and Cotoneaster microphylla. It also springs up in gregarious masses on burnt patches in the Purbani and Poari forests where deodar regeneration has failed in spite of careful burning and sowing.

Scrophularia calycina, Benth. and himalensis, Royle are both common in the outer hills, calycina being typical of the colder spruce-deodar and himalensis of the lower deodar and ban oak-Rhododendron.

Scropularia variegata, Bieb. is confined to the shales and screes of the arid zone - e.g. Rong Gad in the Tidong valley along with Onosma echioides, Hyssopus officinalis, and Polygonum paronychioides.

Wulfenia Amherstiana, Benth. is very common in the spruce forests of the moist zone - e.g. in Gutrang 123A along with Trillium, Polygonatum, and Valeriana Hardwickii under good spruce with only an occasional deodar and blue pine.

Veronica. This genus shows a curious distribution in Bashahr for although many of its species are quite common on the outer hills nearer Simla, they are not much in evidence in the Sutlej moist zone, but are quite a common feature in the alpine forest belt of the dry zone - e.g. V. Beccabunga, Linn. and V. biloba, Linn. in the dry deodar-neoza of Barang and Pangi, and V. arvensis, Linn. in the deodar-juniper association of Purbani 40b at 9500 feet.

Leptorhabdos Benthamiana, Walp. occurs in gregarious patches on hot dry ground in the middle dry and arid zones - e.g. along with juniper scrub in gaps in open deodar forest in Teti Gad; along with Dianthus, Aster, Pimpinella and Senecio in the dry park-like deodar of Rogi; and in Astragalus-Thymus/

Thymus turf in hotter parts of Purbani. Where it occurs with deodar, therefore, it can be taken as indicating difficult conditions for regeneration work and a stumpy and conical height growth.

Pedicularis. Several species are frequent in the damper alpine pastures of the moist and dry zones, and in the turf of the high level blue pine and silver fir forests of Chini and Kailas, P. megalantha, D. Don, P. pectinata, Wall. and P. macrantha, Klotzsch. being the commonest.

OROBANCHACEAE.

Orobanche. Several species are found in alpine and subalpine pasture lands, the commonest being O. Epithymum, DC. which is parasitic on Thymus.

GESNERACEAE.

Chirita pumila, D. Don. occurs on damp cliff crevices in the moist zone - e.g. along with Saxifraga ligulata and Aspidium Prescottianum at 6500 ft. in the Daran Gad above Jakri.

BIGNONIACEAE.

Amphicome arguta, Royle. is common on cliffs and hot rocky ground in the Suttlej gorge and the hotter parts of side-valleys - e.g. along with Capparis spinosa, Phagnalon niveum, and Bosea Amherstiana at Shongtong and in the Bhabba, and with Phlomis spectabilis, Artemisia maritima and the purple grass Pollinia quadrinervis on steep grassy banks at Chagaon.

ACANTHACEAE.

Strobilanthes glutinosus, Nees. is found in the damper types of chil forest in which Quercus incana forms a regular second story - e.g. at Takleh in Nogli Gad.

Strobilanthes/

Strobilanthes Wallichii, Nees. atropurpureus, Nees. alatus, Nees, and Dalhousianus, Clarke, are all typical of the higher forest belts of the moist zone, generally growing in dense gregarious masses to the exclusion of any other undergrowth species, and frequently preventing the regeneration of the forest species in whose shade they grow. All of them are met with in the damp conifer belt where the spruce-deodar mixture gives place to pure Quercus semecarpifolia on the Pandrabis side of the main valley and in the Bhabba, but fading out under dense kharsu oak shade, while in the remainder of the moist zone where kharsu oak does not form such a dense forest belt, Strobilanthes runs higher up into the high level silver fir and the broadleaved forest accompanying it. S. Wallichii and S. Dalhousianus are confined fairly strictly to such situations in Pandrabis accompanied by Arundinaria, Adiantum, Trillium, and Polygonatum. S. atropurpureus and alatus are more widely met with - e.g. atropurpureus is also very plentiful in open irrigated meadow lands in the Chini dry zone along with Anemone rivularis and Geranium Wallichianum, and again in the Bhabba under open deodar and spruce forming with Impatiens scabrida an impenetrable coarse thicket which defies any chance of tree regeneration.

S. alatus also extends towards the middle dry zone, occurring in Kilba in the damper ravines under Aesculus and Rhus succedanea, and throughout the Taranda deodar-spruce zone along with Ainsliea, Astragalus chlorostachys, and Bupleurum Candollei, and again under spruce-blue pine with Viburnum cotinifolium and Polygonum polystachyum.

The analysis of these Strobilanthes species under "shrub" and "perennial herb with persistent woody base" is of doubtful value, because where S. Wallichii, a so-called "shrub", is grazed down, as it invariably is in Bashahr, it is no larger than the other "perennial herbs" whose woody bases are often quite high out of the ground.

Aechmanthera tomentosa, Nees. accompanies Strobilanthes glutinosus under chil pine and ban oak.

Justicia/

Justicia simplex, D. Don. and Dicliptera bupleuroides, Nees. are both common roadside weeds in the hotter reaches of the Sutlej gorge as far as Chagaon, growing amongst Lychnis, Cannabis, and Plectranthus.

VERBENACEAE.

Caryopteris Wallichiana, Schau. and Verben officinalis, Linn. are to be found on the hot lower chil slopes of Nogli Gad amongst grass and along with Berberis, Buddleia, Lilium Thomsonianum, and Desmodium sambuense and concinnum.

LABIATAE.

Thymus Serpyllum, Linn. is a great feature of the dry deodar zone and the alpine grass-lands of dry and arid zones. It is found occasionally in the drier forest grass-lands of Taranda and the Bhabba, e.g. with Mertensia and Anaphalis under open blue-pine, but is not really common until the middle dry zone of Kailas and Chini is reached. In Kilba forests it forms with Leontopodium a turf in the hottest and driest places above the Artemisia belt, and usually marks places as being too dry to grow good deodar. Further up the valley, - e.g. at Barang and Purbani it combines with Astragalus, Oxytropis, Lespedeza, and Lotus to form the leguminous turf which is so typical of the 10,000 ft. belt where deodar gives place to high level blue pine.

In Chini and Kailas also the Thymus occurs at lower levels mixed with Artemisia maritima and Lonicera hypoleuca on the hotter aspects where deodar-neoza gives way to open scrub; but towards the arid zone the Thymus rises in the ecological scale and is commoner in the forest than in the open, and is mixed with Salvia glutinosa, Nepeta supina and Polygonum paronychioides on the milder aspects, avoiding the arid Artemisia-Potentilla-Juniperus scrub of these arid areas.

Plectranthus/

Plectranthus rugosus, Wall. is the commonest shrub of the hot screes and grass-lands of the Sutlej gorge in the moist zone up to Wangtu, beyond which it is replaced by Artemisia maritima. Below the chil belt it forms gregarious masses, mixed in places with Mallotus and Buddleia, and it runs up in the hot Pandrabis grass-lands even to 10,000 ft. along with Inula Cappa, Leptodermis, Androsace, Salvia Moorcroftiana, and S. lanata; and in similar dry grass-lands in Kilba along with Artemisia maritima, Fraxinus zanthoxyloides, Desmodium nutans, and Rhus Cotinus. In the Kilba Quercus Ilex belt it occupies the driest open patches with Daphne oleoides and also penetrates into the deodar zone in mixture with Abelia, Lonicera and Artemisia vulgaris. In this belt and in the Baspa deodar Plectranthus appears to have a toxic action on deodar seedlings, and there is a firm conviction amongst the local villagers, that it is useless to expect deodar regeneration either from natural or artificial sources to prosper where there is a heavy crop of Plectranthus. This also applies to Salvia glutinosa and in the Baspa forests these two often occur together in the lower half of the deodar belt, making regeneration work exceedingly difficult.

Roylea calycina, Briquet (elegans, Wall) is a very common plant in the lower slopes of the dry zone neoza and lower deodar and the grass lands below them. It occurs with Cynoglossum Wallichii and Thymus amongst the prevailing Artemisia maritima, but is best developed on the gentle north and north-west slopes which hold the winter snow longest into the spring.

The previous records of this plant are "Outer Himalaya to 5,000 ft.", but this should be modified to include "Inner Himalaya to 7000 ft.", as the Kanawar plant shows no specific differences other than those caused by heavy browsing.

Salvia. The Salvias form a most interesting group. S. Moorcroftiana, Wall. and lanata, Roxb. are restricted to the hottest low grass lands of the moist zone, but S. glutinosa, Linn. is much more widely met with throughout the valley. It has much the same distribution as Plectranthus rugosus and is common throughout the lower deodar belt in both moist and dry zones. In the outer hills and in the wetter parts of Taranda and Pandrabis, it is more a weed of open waste ground than a forest plant, but in the Bhabba and Panwi Gads, it becomes more typical.

typical of open blue pine and deodar forest, forming a dense bushy scrub with Indigofera, Desmodium, Plectranthus, and Artemisia vulgaris, so thick as to be a serious menace to regeneration of the forest species. On the hotter aspects where deodar keeps to rocky ridges Salvia grows with Caragana brevispina, Plectranthus, and bracken fern up to 10,500 ft., e.g. Yeti in Bhabba valley; and on colder aspects it grows in gregarious masses in the bushy glades of the deodar-Quercus Ilex belt of Kilba with Plectranthus, Artemisia, and Spiraea Lindleyana. In the Baspa it is ubiquitous and occurs with a variety of formations in forest and dry grass-land, but is most marked in the lower deodar, making with Plectranthus a serious obstacle to regeneration work. It is believed by the villagers to have a poisonous effect upon deodar seedlings, and it is quite possible that it has some toxic effect upon them or upon the deodar mycorrhiza.

In the Kailas and Chini ranges Salvia glutinosa is not confined to the lower part of the deodar belt, and it becomes a more typical forest plant, avoiding the hottest types of open scrub. It is very common under quite close deodar canopy, growing with Indigofera, Artemisia vestita, Fragaria, and Thalictrum in the neighbourhood of the Astragalus-Oxytropis-Thymus turf. In the open it frequents sheltered ravines, growing with Spiraea Lindleyana, and in the hotter deodar-neoza forest it is more or less subordinate to Artemisia vulgaris, A. maritima, and Microglossa albens.

The distribution of the common Labiatae is given in tabular form. It is of course only an approximation, for some of the species are so widespread that they can be found in almost any of the formations given.

Damp Forest Type/

DAMP FOREST TYPE.

Broad-Leaved Ravine and
Spruce-Silver fir.

Calamintha Clinopodium,
Benth.
Lamium amplexicaule, Wall.
Leonurus Cardiac, Linn.
Nepeta Clarkei, Hk.
" Govaniana, Benth.
" leucophylla, Benth.
Stachys sericea, Wall.

DRY FOREST TYPES.

Deodar-Blue pine and
Deodar-Neoza.

Ajuga parviflora, Benth.
Craniotome versicolor,
Reichb.
Elscholtzia cristata, Willd.
Mentha sylvestris, Linn.
Nepeta leucophylla, Benth.
" spicata, Benth.
Plectranthus rugosus, Wall.
Roylea calycina, Briquet.
Salvia glutinosa, Linn.
Stachys melissaefolia,
Benth.
Thymus Serpyllum, Linn.

High Level Blue pine.

Elscholtzia polystachya,
Benth.
Nepeta Clarkei, Hk.
" discolor, Royle.
Phlomis bracteosa, Royle.

DAMP MEADOW TYPE.

Calamintha Clinopodium,
Benth.
Prunella vulgaris, Linn.
Stachys sericea, Wall.

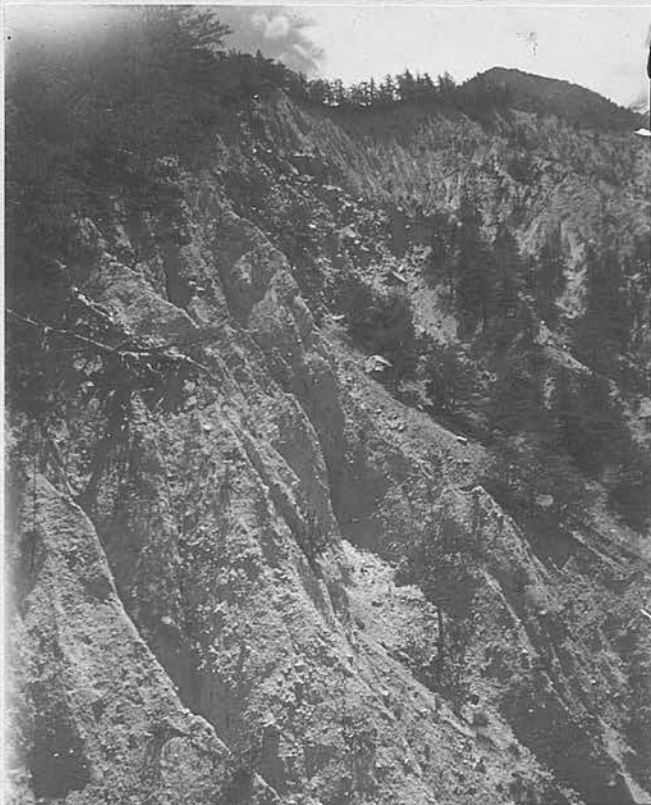
DRY GRASSLAND TYPE,
extending into chil and
neoza forest.

Colebrookia oppositifolia
Sm.
Leucas lanata, Benth.
Meriandra strobilifera,
Benth.
Micromeria biflora, Benth.
Origanum vulgare, Linn.
Plectranthus rugosus,
Wall.
Roylea calycina, Briquet.
Salvia glutinosa, Linn.
" lanata, Roxb.
Moorcroftiana Wall.
Scutellaria repens, Buch-
Ham.
Teucrium quadrifarium,
Buch-Ham.
Thymus Serpyllum, Linn.



EROSION: LATER STAGES.

- (55) 30 acres of Jani forest carried away by landslide in the great storm of September 1924, and since extended by further slips.
- (56) White sand cliffs at Poari, showing (on right) the forest's attempt to reestablish itself.



ARID SCRUB TYPE.

Hyssopus officinalis, Gay.*Nepeta discolor*, Royle" *supina*, Stew.~~*Lactuca Leccardiana*, Clarke~~

PLANTAGINACEAE.

Plantago lanceolata, Linn. is a common field weed, sometimes occurring in warmer spruce-deodar forest.

AMARANTACEAE.

Amaranthus paniculatus, Linn, the common bathu hill crop, is often found as an escape in the forests of the middle deodar belt, e.g. Barang 37c and d.

Bosea Amherstiana, Hk. is fairly common on the hot rocky ground along the bottom of the Sutlej gorge and also in the Bhabba valley bottom.

Cyathula tomentosa, Moq. is exceedingly common along the hot scrub belt of the Sutlej up to Wangtu, but only occasionally beyond this. It grows with *Debregeasia hypoleuca*, *Rhus Cotinus*, and *Desmodium nutans*.

CHENOPODIACEAE.

Chenopodium opulifolium, Schrad. is fairly frequent on waste land near villages, and also comes in very quickly on ground affected by forest fires, or after controlled debris-burning.

Eurotia ceratoides, C.A. Mey. is found only in the arid zone alpine scrub formation along with *Potentilla* spp. and *Cotoneaster microphylla*.

POLYGONACEAE.

POLYGONUM.

Several of the common *Polygonums* of the outer hills occur in the moist zone as forest undergrowth - e.g. *P. chinense*, Linn. in shady broad-leaved ravines and under damp spruce; *P. serratum* Lag. (*P. Donii*, Meissn.) along water channels even in the arid zone; *P. alatum*, Buch-Ham. as a weed in fields/

fields and on any prepared ground in nurseries, and P. pterocarpum, Wall. which becomes a nuisance as a rampant creeper in nurseries (e.g. Shoang 24 in Baspa).

Polygonum polystachyum, Wall. and amplexicaule, D. Don form a more shrublike growth, making almost impenetrable thickets in the steep stream beds of the Bhabba, Kilba, and the Baspa, often pure, but also mixed with Impatiens scabrida, gigantea, and racemosa, and Spiraea Lindleyana. They also occur scattered and with a much reduced foliage in most of the damper types of forest.

Polygonum molle, D. Don, and affine, D. Don grow in similar dense masses but are not so rampant in their growth as polystachyum and as a rule are at higher elevations, - e.g. in the Bhabba blue pine belt and in the alpine meadows of Chini Kanda, in the neighbourhood of Cassiope, Saxifraga, Potentilla, and Geum. They also occur with deodar in arid zone reentrants.

Polygonum vacciniifolium, Wall. and paronychioides, C.A. Mey. are creeping shrubs of the dry and arid zone alpine belt, vacciniifolium being common in Kailas above 10,000 ft. along with Potentilla rigida, Morina, and the alpine Rhododendrons, while paronychioides is a real arid zone type, growing on the shale slopes of the Tidong and Nisang along with Hyssopus, Allium, Rheum, Ephedra, and Juniperus.

Rumex hastatus, D. Don is fairly common along the cliffs and rock screes of the Sutlej gorge in Kilba and Kailas along with Capparis spinosa and Bosea Amherstiana and on screes at the level of the lower deodar belt along with Verbascum, Silene, and Artemisia in the middle dry zone. It is also a feature of arid zone shale screes along with Rheum and Hyssopus.

Rheum Emodi, Wall. and spiciforme, Royle. are common in the dry and arid zones, growing on shaly ground with Allium, Hyssopus, and Nepeta supina and on more stable ground in the high level blue pine and dry deodar-neoza forests with Lonicera hypoleuca, Berberis, Caragana and Polygonum paronychioides. R. Emodi is more typical of the middle hills/

hills and spiciforme of the further arid tracts.

LAURACEAE.

Machilus Duthiei, King and Litsea umbrosa, Nees. are both fairly common in the moist warm shady undergrowth of the ravine bottoms of Taranda and Pandrabis, where the forest canopy is fairly dense. They are usually in the company of Daphne, Sarcococca, and Skimmia.

THYMELACEAE.

Daphne oleoides, Schreb. is a common bush on the dry open slopes of the Sutlej below 9000 feet from Kilba to Jangi, but it avoids the side valleys. In Kilba, it grows with Plectranthus and Artemisia maritima and vulgaris below the neoza belt, and with Abelia and Lonicera in the Quercus Ilex-deodar area, while beyond in the drier Kailas-Chini sector it grows with Lonicera hypoleuca, Artemisia maritima, and Colutea, up to and amongst the open neoza-deodar stands.

Daphne papyracea, Decne. (cannabina, Wall) is fairly common in the damper parts of Taranda and Pandrabis under spruce-deodar and spruce-blue pine canopies, along with Rubus spp., Litsea, Skimmia and Viburnum.

Wikstroemia canescens, Meissn. occurs rather erratically in fairly dry deodar forests, - e.g. Barang 37f along with Anaphalis Royleana, Microglossa, and Ribes Grossularia, - and again in Ribba 44a with Hyssopus officinalis, Nepeta linearis and Lonicera hypoleuca.

ELAEGNACEAE.

Elaeagnus umbellata, Thunb. is a fairly common shrub on the dry open slopes of the Sutlej in Taranda and Kilba but is seldom found under forest canopies.

Hippophae rhamnoides, Linn. and salicifolia D. Don. are dry zone types, common along stream sides/

sides in the drier half of Pandrabis, the Baspa, and other Kailas and Chini valleys along with Spiraea Lindleyana, Polygonum polystachyum and Impatiens spp. H. salicifolia is restricted to stream banks, while rhamnoides extends to dry alpine scrub areas, e.g. Rupin above the Baspa at 11000 ft. under very open blue pine. The usual rhamnoides is an intermediate form between Parker's Var. 1 and Var. 2 while his Var. 3 is only found in arid alpine belts at 12,000 ft.

LORANTHACEAE.

Loranthus vestitus, Wall. is the only Loranthus at all common in Bashahr, and it is confined to Quercus incana and occasionally other broad-leaved trees in the moist zone.

Viscum album, Linn. is common on Prunus and Pyrus both in cultivation and in the broad-leaved forests of the moist zone, while V. japonicum, Thunb. is confined to Quercus Ilex in the dry zone.

Arceuthobium minutissimum, Hk. the smallest dicotylodinous plant, is exceedingly common as a parasite on the dry zone high level blue pine and its effect upon the distribution of Pinus excelsa is discussed in Chapter VII.

EUPHORBIACEAE.

Euphorbia Royleana, Boiss. is quite a feature of the cliffs and steep hot grass slopes of the Sutlej gorge in the moist zone, as it flourishes on ground too hot and rocky to support Pinus longifolia. It is confined almost entirely to the Pandrabis southern exposure, and at Jakri persists on hot cliffs up to 5200 ft. Its nearest neighbours are usually Pinus longifolia, Pistacia, Plectranthus, and Buddleia,

Euphorbia Maddeni, Boiss. is the commonest of the herbaceous Euphorbias, several of which occur in the damper subalpine grasslands.

Buxus Wallichiana, Baillon (B. sempervirens, Linn. ex parte) occurs gregariously in a few very restricted areas in the Pandrabis valley bottoms - e.g. Sadholi Gad, a branch of the Ganwi valley.
Its/

Its requirements are similar to ash and walnut, i.e. a damp but well drained soil in sheltered valleys where it forms pure dense pole crops. The ground below it is absolutely clean of all vegetation when it grows pure, but where it forms part of the second story of mixed broad-leaved stands, its associates are occasional large spruce, Fraxinus micrantha, Ulmus laevigata, Populus ciliata, Machilus, Litsea, Polygonatum and some orchids and ferns.

Sarcococca saligna, Muell. (pruniformis, Lindl.) is fairly common in the damper forests of Pandrabis and Taranda, sometimes gregarious in large patches under open stands of Aesculus, Carpinus, or Ulmus, at other times mixed in denser undergrowth with Machilus, Litsea, Skimmia, and Meliosma.

Andrachne cordifolia, Muell. is found occasionally in the hot open grass-lands of Pandrabis along with Oxalis and Androsace.

Mallotus philippinensis, Muell. occurs in fairly dense gregarious clumps in the hot lands along the Suttlej from the outer foothills up to Jakri, and infrequently beyond that up to Kilba. Its habitat is hot open scrub below the chil pine belt in the company of Sterculia, Plectranthus, Rhus, Cotinus, and Desmodium nutans on hotter ground than Dalbergia, Cedrela, or Bauhinia though at much the same level as these.

URTICACEAE.

Ulmus Wallichiana, Planch. and laevigata, Royle are both members of broad-leaved forest formations in the moist zone and are cultivated for lopping near villages. U. laevigata frequents a lower level and is common along the bottoms of the Pandrabis valleys where these are deep and narrow, e.g. Salarang Gad, along with box, alder and maple with a thick ground cover of Polygonatum spp., orchids and ferns. U. Wallichiana keeps to the same type at higher elevations and also to the more open hillsides where the regular thach type of forest is produced in hollows between the conifer-clad ridges.

Celtis australis, Linn. occurs irregularly in broad-leaved forest formations throughout Bashahr from Pandrabis to the Baspa and Kailas, It is not a regular/

regular member of the broad-leaved thach formation of Pandrabis, but is common on the steeper banks of most side-streams there, along with Ulmus laevigata, box, alder, and maple, e.g. Salarang, Gad, - and in Taranda with Cornus, Viburnum, Carpinus and Aesculus - e.g. Chaunda Gad. Celtis persists in the moister ravines right through the dry zone into Kailas and Chini, but is nowhere found in any quantity, single trees occurring scattered amongst Rhus succedanea and punjabensis, Viburnum, Parrotia, Quercus Ilex (and less commonly Q. dilatata, e.g. in Lishnam Gad), Staphylea and Deutzia.

Parker has indicated in his "Punjab Flora" that there might probably be a new species of Celtis intermediate between C. australis, Linn. and C. alpina, Royle or C. caucasica, Willd., and I discussed this with him while working in Dehra Dun herbarium. In practice, however, I found it was not feasible to separate them, for even in the dry and arid zones the Celtis, although much reduced in leafage, agrees more closely with C. australis than with either of the other two specific descriptions. It appears probable that the arid zone type of Celtis may be more highly developed further west in Pangi and Kishtwar than it is in Kanawar where constant lopping has perhaps interfered with the natural evolution of a more definite dry zone type.

Villebrunea frutescens, Blume, occurs in the Baspa valley on the hot valley slopes below the deodar belt, forming a dense thicket with Acer pentapomicum, Viburnum, Lonicera, and Abelia, but it is nowhere common.

Debregeasia hypoleuca, Wedd. occurs along the hot Suttlej river-side in an open scrub association along with Cyathula tomentosa and Mallotus on ground from which heavy browsing has driven out the more usual Olea-Fraxinus formation along roadsides in the valley bottom - e.g. Wangtu and Chagaon.

Morus serrata, Roxb. is widely cultivated in Bashahr in village lands and along the edges of terraced fields, and is invariably heavily lopped for fodder. Escapes are occasionally met with in the shelter of broad-leaved formations along ravine banks.

Ficus foveolata, Wall and Roxburghii, Wall are the only figs which are at all common, and even they are restricted to the valley bottoms, foveolata occurring/

occurring in some of the moist zone broad-leaved formations, e.g. as an undergrowth to Cornus and Aesculus in Chaunda Gad, while Roxburghii is a companion of the chil pine up to Wangtu.

Cannabis sativa, Linn. is one of the commonest roadside weeds throughout the valley up to 10,000 ft, and towards the arid zone as far as Pangl, coming up in dense clumps after summer rains wherever goats and sheep have been camping and also on all waste ground immediately around habitations. In the moist zone its usual companions are Girardinia, Pilea, Valeriana, and Cordyalis; towards the dry zone there is Impatiens scabrida, Verbascum, and Hyoscyamus, while along the hot Sutlej gorge camping grounds there is Diclyptera, Lychnis and Salvia glutinosa.

Urtica dioica, Linn. is fairly common in the shade of spruce in the moist zone spruce-blue pine and spruce-deodar, but is restricted to the lighter undergrowth as it cannot compete with the coarser growth of such plants as Strobilanthes and Girardinia. Its usual companions are Nepeta, Bupleurum, Adiantum, Ainsliaea, Fragaria, and Galium.

Girardinia palmata, Gaudich, (heterophylla Decne.) and Pilea umbrosa, Wedd. are typical of the moister zone where spruce stands open out over stony screes to form fairly sheltered gaps in the forest canopy. Their usual companions are Leonurus Cardiaca, Impatiens spp., Corydalis rutaefolia, and in more open places near villages Cannabis sativa.

JUGLANDACEAE.

Juglans regia, Linn. is fairly common growing naturally in moist ravines on deep well-drained soil throughout Pandrabis and Taranda and to a less extent in the side valleys of Kilba and lower Chini, usually along with Aesculus, Cornus, Celtis and Acers, with a very varied ground flora of herbs and ferns though not many shrubs. It is also cultivated widely for its fruit and fodder production, being lopped on a two-or three-year rotation in village lands. The cultivated form is a very poor one for fruit production and the walnuts from the village trees are usually quite as thick-shelled as the wild ones, only a very few well known trees in/



FOREST TYPES:- BROAD-LEAVED SPECIES.

- (57) Alnus nitida forming dense high forest in a dry zone stream bed near Kilba.
- (58) Aesculus indica forming pure woods at 8,500 feet in Kandrad Gad, Pandrabis Range.



in each village yielding thin-shelled nuts.

CUPULIFERAE.

Alnus nitida, Endl. is strictly confined to stream beds and banks in their vicinity, but within this habitat it occurs very regularly throughout Bashahr. In the damper parts of Pandrabis it runs up the hillsides some distance, mixing with Corylus, Pyrus, Prunus, and Aesculus in the lower thach formation, but in Kilba and lower Chini it forms pure stands with an underwood of Cornus and Viburnum and a dense crop of herbs such as Valeriana Hardwickii, Ranunculus hirtellus, Corydalis ramosa, Impatiens spp. and ferns such as Nephrodium barbigatum and Pteris cretica. These together form a moisture-loving association which penetrates into the dry zone under cover of the alder canopy at 5000-6000 feet in the same way as deodar brings its own associates with it at 8,000 - 9,000 feet.

Betula utilis, D. Don. is typical of the upper tree limit growing in open but gregarious stands under scattered silver fir in the upper edge of the conifer belt, and above this with Rhododendron lepidotum and Pyrus foliolosa in the moist alpine, and with Prunus Jacquemontii and Pyrus Aucuparia in the drier alpine conditions of Kilba and Kailas.

Betula alnoides, Buch-Ham. is mixed in the lower edge of the alpine birch belt with B. utilis and extends from there downwards to join in the higher thach formation with Corylus, Pieris, Pyrus, and Cornus. It is also common on the steeper sides of ravines where the spruce-deodar forest is opening out and before these other broad-leaved species have come in. In the Baspa it comes down to the riverside above Bassering.

The specific differences between these two birches as detailed by Parker are difficult to apply because many individuals fall between the two extremes. The local name for B. utilis, "bhojpattra", is applied by the Kanawari to both species.

Carpinus viminea, Lindl. and faginea, Lindl. are found growing together in certain restricted ravine bank areas - e.g. Chaunda Gad in Taranda - in company with Cornus, Aesculus, and Alnus. They are dependent/

dependent on a good supply of subsoil moisture and shelter from the hot Sutlej valley wind. but they apparently cannot compete with the more robust Alnus in the ranker growth of ravine bottoms.

Parker in his "Punjab Flora" mentions that C. faginea replaces C. viminea in the inner hills, but I have not recognised either of them anywhere in the Sutlej valley beyond Chaura, although in these Taranda ravines faginea is commoner than viminea.

Corylus Colurna, Linn, is a common member of the broad-leaved thach communities of Pandrabis and Taranda already described. As the middle dry zone is reached the thach type becomes more restricted in its distribution, keeping more definitely to ravine bottoms and depressions, but the Corylus as an individual becomes much more frequent and more dominant within the formation - e.g. in Lishnam Gad and some of the Baspa side-streams.

SALICACEAE.

Salix. The common willows which form gregarious patches of tall bushes in the damper portions of the dry zone deodar belt are Wallichiana, Anders., denticulata, Anders. (elegans, Wall), daphnoides, Vill. and hastata, Linn., the last being more typical of the upper deodar and silver fir belts, and the other three being more or less interchangeable from Panwi to Boktu, though best developed as an undergrowth type in Kailas range.

Dwarf shrubs of the alpine arid country on the Tibetan border are S. furcata, Anders., and S. flabellaris, Anders., and these are also found in the alpine belt of the middle dry zone amongst dwarf Rhododendrons and with Cotoneaster microphylla amongst scattered silver fir where the cushion-scrub type of arid zone vegetation first develops and replaces the moist alpine grass-lands in Kilba and Lower Chini.

Other willows found are:- S. tetrasperma, Roxb. only found at a few sheltered places along the main valley bottom - e.g. at the mouth of Panwi Gad.

S. viminalis, Linn. is fairly common on the hot shingle beaches of the Baspa along with Myricaria and Hippophae.

S. oxycarpa, Anders. and S. fragilis, Linn. are the irrigated species of the arid zone villages. Willow cuttings are planted along all water channel banks and lopped on a two-or three-year rotation for fodder in all villages beyond Chini, and best developed in Pu and Thangi.

Populus ciliata, Wall. and to a less extent P. alba, Linn. are grown from cuttings along the banks of irrigation channels throughout the upper valley beyond Chini.

P. ciliata only occurs wild in the moist zone, being fairly common as an early migrant on loose screes and rock slides. It persists occasionally as a large forest tree amongst deodar along the lower slopes of the Bhabba valley and amongst broad-leaved trees in the thach formation of Pandrabis.

DIOSCOREACEAE.

Dioscorea melanophyma, Prain and Dioscorea deltoidea, Wall. are quite common as climbers over the bushes of open blue pine and deodar forests of the Baspa valleys and also in the damper parts of the deodar-neoza belt in Kilba and Chini.

LILIACEAE.

Smilax parviflora, Wall. and vaginata, Decne. are both fairly common in deodar-blue pine forests in Taranda and Kilba, forming a fairly close ground cover with Fragaria, Viola, Adiantum and Asparagus filicinus in blue pine pole woods in which deodar is beginning to find a footing. It is usually associated with the best type of deodar-blue pine crop in the moist zone.

Asparagus gracilis, Royle, is a plant of fairly good dry deodar undergrowth in Kilba and Kailas, growing generally along with Anaphalis nubi-gena, Adiantum, Fragaria, and Viola as a carpet under occasional Indigofera and Desmodium. In the moist zone it appears in the bushy scrub of the lower deodar belt along with Plectranthus, Salvia glutinosa, Artemisia vulgaris and Jasminum humile - e.g. Chota Kamba, Compartment 110.

Asparagus filicinus, Buch-Ham. is typical of moist zone spruce-deodar and blue pine undergrowth/

undergrowth, growing along with Ainsliaea, Trillium, Polygonatum, Valeriana, Wallichii, and Wulfenia Amherstiana in shade, and also in grassy forest glades in this belt with Hedychium, Clematis, Spiraea and Berberis.

Asparagus adscendens, Roxb. is restricted to the hot grass-lands of the Suttlej gorge and the lower side-streams, growing below 5,000 ft. as a straggly bush along with Plectranthus, Buddleia, Roylea, Rhynchosia, and Caesalpinia along the lower fringe of the chil belt.

Polygonatum multiflorum, All. verticillatum, All., and less commonly cirrhiifolium, Royle, (sibiricum, Delar.) are common under damp spruce-deodar and broad-leaved canopies in Pandrabis along with Polygonum amplexicaule, Strobilanthes, Ainsliaea, Asparagus filicinus, Fragaria, Viola, Habenaria, and Aspidium aculeatum. They also occur somewhat unexpectedly in the undergrowth of certain dry deodar forests of Chini and Kailas, along with Indigofera Gerardiana, Salvia glutinosa, Artemisia vestita, Lonicera angustifolia, and Microglossa albescens as a scattered shrub growth over a ground cover of Fragaria and Astragalus-Thymus turf, - e.g. Barang 37c and Boktu 80b.

Allium rubens, Baker (lilacinum, Royle) and Wallichianum, Steud. (Wallichii, Kunth) occur irregularly in moist spruce-deodar forest along with Corydalis, Chaerophyllum, Trillium, and Strobilanthes in the neighbourhood of the Arundinaria bamboo but on ground too well shaded for the latter to persist.

Allium atropurpureum, Waldst. (stenopetalum, Boiss) is an arid zone plant occurring on shale screes in the further uplands of the Tibetan border along with Hyssopus officinalis, Adonis scrobiculata, Onosma echioides, and Polygonum paronychioides.

Lilium polyphyllum, D. Don is plentiful in a few restricted areas of deodar forest - e.g. Runang 89 deodar plantation, under the partial shade of a fine old deodar crop accompanied by Asparagus gracilis, Rubus niveus, Chaerophyllum villosum, and Potentilla nepalensis, in addition to the usual dry zone deodar shrubs such as Berberis, Lonicera, Microglossa, and Abelia. Further along towards the arid zone in Boktu it appears under the best deodar stands with Philadelphus tomentosus, Thalictrum neurocarpum.

neurocarpum, Polygonum, Bupleurum and Dioscorea.

Lilium Thomsonianum, Lindl. (roseum, Wall) is fairly common in hot grass-lands at the bottom of Nogli Gad and the Bhabba valley below 5,000 ft. along with Salvia lanata and Androsace rotundifolia.

Trillium Govanianum, Wall. and Fritillaria Roylei, Hk. are fairly plentiful in certain types of damp spruce in Pandrabis along with Polygonatum spp., Strobilanthes, and Ainsliaea, sometimes extending to damp broad-leaved forest along with Chaerophyllum, Aspidium ilicifolium and aculeatum, Corydalis and Allium.

ORCHIDACEAE.

Bashahr is relatively poor in orchids owing to the enormous area of ground which is too dry for them, and also to the very heavy grazing which takes place over most of the sites in which orchids might be looked for. The following list is not by any means exhaustive, and merely indicates those actually met in the course of forest work.

Spiranthes australis, Lindl. - in lush meadows in the Baspa valley.

Goodyera repens, R. Br. - Kailas dry zone high level silver fir.

Cephalanthera ensifolia, Rich. - Nichar damp spruce-deodar forest.

Habenaria pectinata, D. Don. (ensifolia, Lindl). - in damp, warm ravine bottoms in Pandrabis.

Satyrium nepalense, D. Don. - open blue pine forest in Taranda moist zone.

Of these only Spiranthes, Habenaria, and Satyrium occur in sufficient quantity to make them of any value as indicators.

SCITAMINEAE.

Roscoeia elvator, Sm. (alpina, Royle) is locally very common in some of the Taranda deodar blue pine forests, e.g. Taranda, Compartment 126b plantation, along with Gentiana argentea, Ajuga parvifolia, Ainsliaea, Adiantum, and Viola, and again under damp blue pine at a higher level with Potentilla Geum.

Geum, and Arisaema.

Roscoea spicata, Sm. occurs occasionally under dry deodar canopy, - e.g. Yeti in the Bhabba along with Thalictrum minus, Nepeta leucophylla, and Bupleurum Candollii under less than the usual amount of open bush growth of Rosa, Desmodium, and Abelia.

Hedychium spicatum, Sm. (acuminatum, Rosc.) is fairly common in the open scrub of ravines in the moist zone along with Spiraea Lindleyana, Berberis, Asparagus filicinus, Clematis, and Arisaema.

Musa rosacea, Jacq. occurs as a few groups of dense stoloniferous growth congregated immediately around hot springs, several of which are found along the hot valley bottom in Taranda Range.

IRIDACEAE.

Iris kumaonensis, Wall. and Iris nepalensis, Don, are found in open blue pine forest forming dense carpets of perhaps half an acre in extent in forest glades in which no other plant can establish itself e.g. Lishnam Gad and Urni Compartment 94. I. kumaonensis occurs at slightly higher elevations (about 10,000 ft. compared with nepalensis at 8 - 9,000 ft.) but they are otherwise alike in their habitat.

COMMELINACEAE.

Commelina obliqua, Buch-Ham. is fairly common at low levels as a roadside weed along with Lychnis and Diclyptera, and in damp ground around villages along with Cannabis sativa.

Cyanotis barbata, D. Don is found in damp crevices of the Taranda cliffs and occasionally in damp spruce-deodar forest.

JUNCACEAE.

Several of the Juncus family, chiefly J. bufonius, Linn. and J. himalensis, Klotsch., are found in damp meadow lands but none of them occupy large areas of ground and they seldom occur under forest canopies.

ARACEAE/

ARACEAE.

Arisaema intermedium, Blume, Wallichianum, Hk. and Jacquemontii, Blume are fairly common in the moist zone under open stands of blue pine along with Salvia glutinosa, bracken, Elscholtzia cristata, and Anaphalis araneosa, and under damper blue pine and spruce mixtures with Potentilla, Geum and Roscoea. Occasionally also A. intermedium is found in the scrub of damp ravines.

CYPERACEAE.

Several of this group occur fairly commonly in the damp meadows of the moist zone, generally below the level of the deodar-spruce belt - e.g.:-

Carex condensata, Nees.
Cyperus aristatus, Rottb.
 " *niveus*, Retz.
Eriophorum comosum, Nees
Fimbristylis Pierotii, Miq.
Pycneus nitens, Nees.

GRAMINEAE.

The following is a very rough classification of the commoner grasses and the ecological types to which they belong in Bashahr. The list is only an approximation and several of the species are doubtfully named as I was unable to have any of the names checked and I had only Collett's "Flora Simlensis" as a guide.

DAMP FOREST. *Dactylis glomerata*, Linn.
Erianthus fulvus, Nees.
Melica scaberrima, Hk.
Oplismenus undulatifolius, Beauv.
Oryzopsis aequiglumis, Duthie.
Panicum plicatum, Lam.
Pennisetum flaccidum, Griseb,
 (incomptum Nees.)

DAMP MEADOW. *Festuca kashmiriana*, Stapf.
 (occasionally in Forest) *Koeleria cristata*, Pers.
Paspalum ambiguum DC. (*panicum glabrum* Gaud.)
Phleum alpinum, Linn.

DRY/

- DRY FOREST. *Agropyron longearistatum*, Boiss.
 Agrostis Royleana, Trin.
 Andropogon tristis, Nees.
 Apluda aristata, Hack. (varia, Hack)
 Avena aspera, Munro.
 Calamagrostis littorea, DC.
 Stipa sibirica, Lam.
 DRY GRASSLAND. *Andropogon contortus*, Linn.
 " *Gryllus*, Linn.
 " *Ischaemum*, Linn.
 Arthraxon submuticus, Hochst.
 (ciliaris, Beauv.)
 Avena fatua, Linn.
 Cynodon Dactylon, Pers.
 Festuca Myuros, Linn.
 Lolium temulentum, Linn.
 Poa pratensis, Linn.
 Pollinia quadrinervis, Hack.
 Spodiopogon dubius, Hack.
 ARID SSCREENS. *Agrostis alba*, Linn.
 Eragrostis nigra, Nees.
 Perotis latifolia, Ait.
 Phleum arenarium, Linn.
 Setaria viridis, Beauv.

Arundinaria falcata, Nees, and less commonly *A. spathiflora*, Trin. at higher elevations, is a feature of the damper spruce-deodar forests of Pandrabis, forming dense thickets and gregarious clumps on the cooler aspects where the spruce is dominant and the deodar is only occasional. It avoids the hot slopes where blue pine comes in naturally, and only occasionally invades the lower level of *Quercus incana* - *Rhododendron arboreum*, where it loses its gregarious character and mixes with *Spiraea Lindleyana*, *Buddleia*, *Deutzia*, and *Acer*. In the true spruce belt *Arundinaria* appears to indicate ground conditions intermediate between the damp ravines with their broad-leaved crop and the drier ridges where spruce gives place to deodar and blue pine.

It is possible that *A. Falconeri*, Gamble and *jaunsarensis*, Gamble occur in the Pandrabis forests adjoining the Kulu boundary and in Taranda along the Pabar watershed, but so far as I have found the above are the only bamboos in this area.

GNETACEAE.

Ephedra Gerardiana, Wall. (vulgaris, Hk.) and intermedia, Shrenk and Meyer (pachyclada, Boiss.) are exceedingly common in the arid zone, forming with Artemisia maritima practically the only vegetation over miles of hillside in the Ropa and Nisang valleys and in the main Suttlej valley up to the Tibetan border. The specific differences between the two species are very indefinite and the ecological characteristics of both are identical. In the arid zone Ephedra is not so ubiquitous as Artemisia and is confined to the rockier ground, when better soil is occupied by Artemisia, Rosa Webbiana, Colutea, and at higher elevations Juniperus and Cotoneaster microphylla. Towards the middle dry zone it appears first as a pure rock plant on the Shongtong cliffs along with Rumex hastatus and Capparis spinosa.

FILICES.

Ferns are relatively infrequent in the upper Suttlej, but several of them play a very definite role as ecological indicators. The following is probably not an exhaustive list, but are only the ones found by myself and traced with the aid of Hooker's "Synopsis Filicum", and I believe that the list includes all the ferns of any importance in the area.

SPRUCE and BROAD-LEAVED FOREST.

Aspidium (Polystichum) Prescottianum, Hk. -
Taranda spruce forests, very common.
Aspidium (Polystichum) ilicifolium, Don. } Under rocks in Pandra-
bis and Taranda; both
Aspidium (Polystichum) aculeatum, Sw. } common.
Cheilanthes subvillosa, Hk.
Polypodium (Goniophlebium) amoenum, Wall.

SPRUCE and DAMP DEODAR.

Adiantum Capillus-Veneris, Linn. - very common throughout damper deodar forests.
Adiantum venustum, Don. - replaces A. Capillus-Veneris in a few places.
Pteris cretica, Linn. - favours windless sheltered ravines.
Nephrodium/



HIGH-LEVEL BLUE PINE FOREST.

- (59) Rampant bracken undergrowth in open blue pine; Runang forest in Chini Range, 10,200 feet.
- (60) Dense mat of Iris kumaonensis in open blue pine forest; Urni in Lower Chini, 10,400 feet.



Nephrodium (Lastrea)

- | | | | |
|---|---|-------------------|--------------------------|
| " | " | Brunonianum, Hk.) | Common |
| " | " | barbigerum, Hk.) | throughout |
| | | |) moist zone. |
| " | " | sparsum, Don.- | replaces previous two in |
| | | | dry zone. |

Polypodium (Phymatodes) lineare, Thunb - common up to Kilba.

Adiantum is much the most useful of the ferns ecologically. It is a constant member of the spruce ground flora along with Ainsliaea in the drier portions of the spruce forest where deodar can be expected. It also extends into the blue pine-deodar belt in the moist zone and as far up the valley as Kilba along with Fragaria, Viola, and Thalictrum in areas where all three conifers (deodar, spruce, and blue pine) do equally well. It indicates a rich soil which will grow a rampant crop of weeds if the canopy is removed.

PURE BLUE PINE:- Pteris aquilina, Linn. - bracken, very common under open pine. Osmunda Claytoniana, Linn. under open Occasional dense gregarious masses in Baspa and Lower Chini.

DEODAR-BLUE PINE. Asplenium nigripes, Blume.
" maximum, Don.
Aspidium (Polystichum) aristatum, Sw.
Nephrodium (Lastrea) Boryanum, Baker.

DRY DEODAR-NEOZA:-

- Cystopteris fragilis, Bernh. -
Baspa deodar.
Asplenium (Hemidictyum) Ceterach,
Linn. under Quercus Ilex.
Asplenium Trichomanes, Linn. - under
stones up to Jangi.
Asplenium fontanum, Bernh.- under
stones in arid zone replacing A.
Trichomanes.
Polypodium subdigitatum, Blume.) Chini
" (Phegopteris) } deo-
Dryopteris, Linn. } dar.
Gymnogramme (Leptogramme) aurita,
Hk. under Quercus Ilex.

SUTLEJ GORGE below 5000 feet:-

Adiantum/

Adiantum lunulatum Burn.- on hot dry cliffs and rock crevices.

DRY ZONE WATER-COURSES:-

Dicksonia appendiculata, Wall.

Pteris pellucida, Presl.

CONIFERAE.

Juniperus communis, Linn. (and to a less extent squamata, Buch-Ham. and pseudosabina, Fisch.) forms dense masses of procumbent shrub in the arid alpine and subalpine zone, being first in evidence at Barang in Kailas and at Rogi in Chini, where it forms an undergrowth to dry deodar-blue pine at about 10,000 feet. This type of undergrowth becomes increasingly common in the arid zone deodar forests in the Tidong and Teti valleys, ^{and} also forms the only vegetation along with Cotoneaster microphylla over large expanses of the arid zone above 9000 feet - e.g. Ropa and Nisang Gads. Where it occurs as patches in the middle dry zone deodar forest it indicates a distinct local increase in aridity.

Juniperus macrocarpa, Boiss. occurs infrequently in small isolated patches of forest at about 12,000 feet in some of the dry and arid zone valleys - e.g. Yula and Kashang Gads in Chini - and more generally as scattered stumpy trees in very dry deodar forest at 9 - 10,000 feet - e.g. Skibba in Kailas and Teti Gad in Chini.

Taxus baccata, Linn. is found under very dense shade in the moist zone spruce and silver fir forests of Taranda and to a less extent in Pandrabis. It appears to be able to reproduce itself in very dark places and as a rule there is no ground flora below it at all. Occasionally also it reproduces freely under fairly open stands of old spruce and once established makes any spruce or silver fir regeneration exceedingly difficult..

. C H A P T E R I X .

DEODAR TIMBER PRODUCTION.

The primeval deodar forests on the more accessible slopes were heavily cut out by early traders, and much of the remaining over-mature stock has since been removed under the Working Plan prescriptions, so that the supply of very large deodar has to a great extent disappeared. Enough is left, however, to corroborate the statements of early travellers such as Jacquemont, Gerard, and Thomson, who were amazed at the quality of the deodar forests of Nichar and Kilba. This dry zone deodar is of slower growth than in the outer hills of Simla and Kulu, however, and the average age of these fine old forests was 300 years or more.

Under modern conditions it is impossible to replace such crops, and the most that can be hoped for is a rotation that will produce trees with an average girth of 7'6". Meanwhile the recent re-enumeration of the growing stock shows an acute shortage of middle-aged trees, and there will be great/

great difficulty in bridging over the gap between the harvesting of the remaining over-mature forests and the maturing of the many fine pole woods which have come up in the early felling areas.

It is thus vitally important to determine the earliest age at which the various types of deodar crops can be felled profitably. FIG. 11 showing the average rate of growth for each of the five ranges indicates the very great differences which exist between the moist and dry geographical units. These curves are only for stump ring-countings, however, while the quantity of timber produced by a given tree is governed by the length and shape of the bole, or "form factor". In the case of the Suttlej deodar the market requirements are mainly for railway sleepers with a minimum of sapwood, and the yield from trees of small girth is disproportionately small.

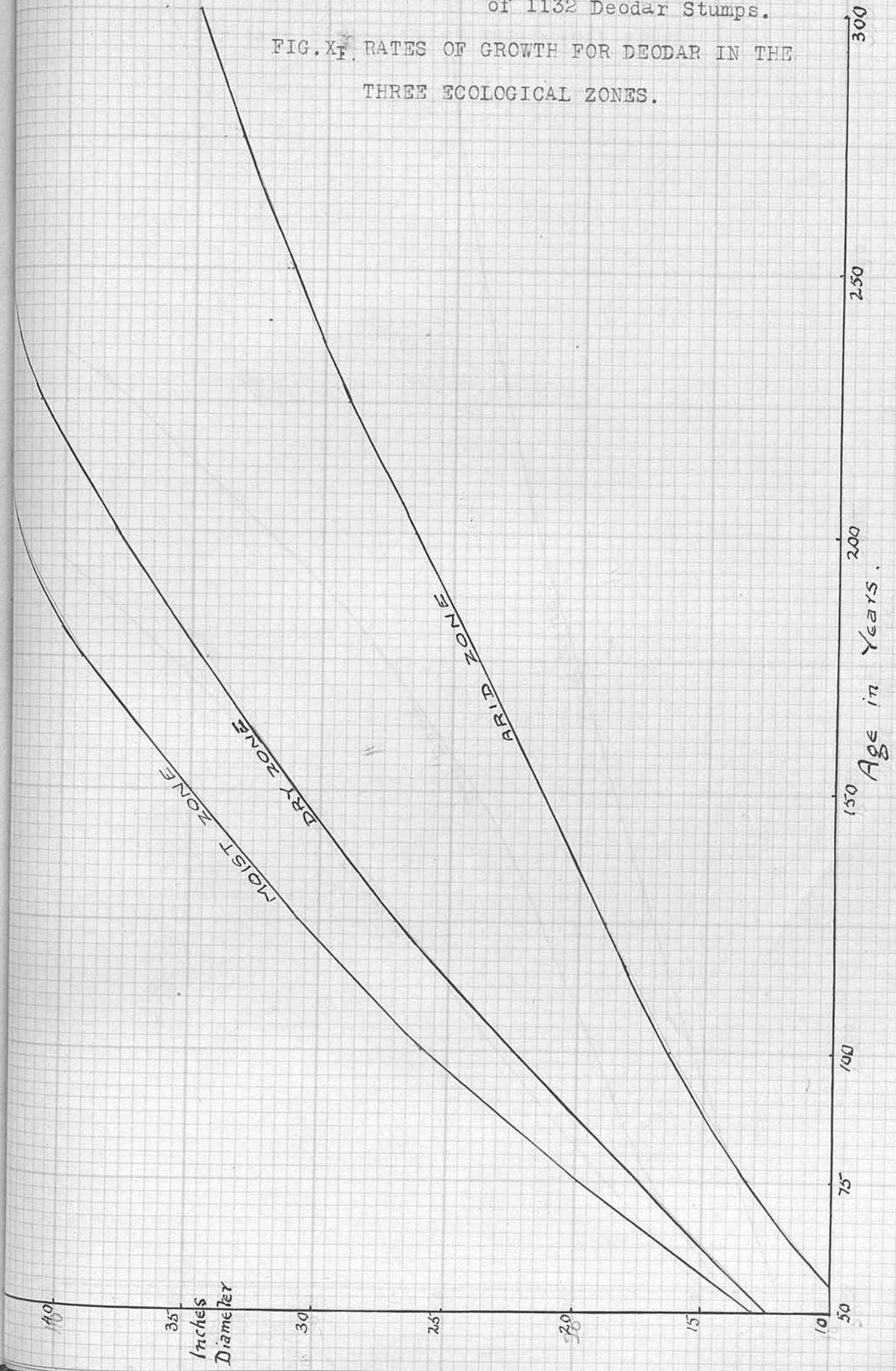
In order to determine the timber yield of the various types of deodar, I collected data from the various forests which were being worked during the three years I was in charge of Upper Bashahr, and the results are shown in the accompanying graphs.

FIG. 12 shows a comparison of the average production/

Age v Diameter from Ring-countings

of 1132 Deodar Stumps.

FIG. XI. RATES OF GROWTH FOR DEODAR IN THE
THREE ECOLOGICAL ZONES.



production by commercial log volume up to an 8-inch diameter for each of the three climatic zones. Within each zone, however, the variations in sawn timber output are even greater, and the remaining graphs (FIGS. 13 to 15) show the variations which may be expected between the sawn timber yield of the optimum type and the inferior types for each of the three zones. An abstract from these graphs is given below to indicate the variations in output between the three zones.

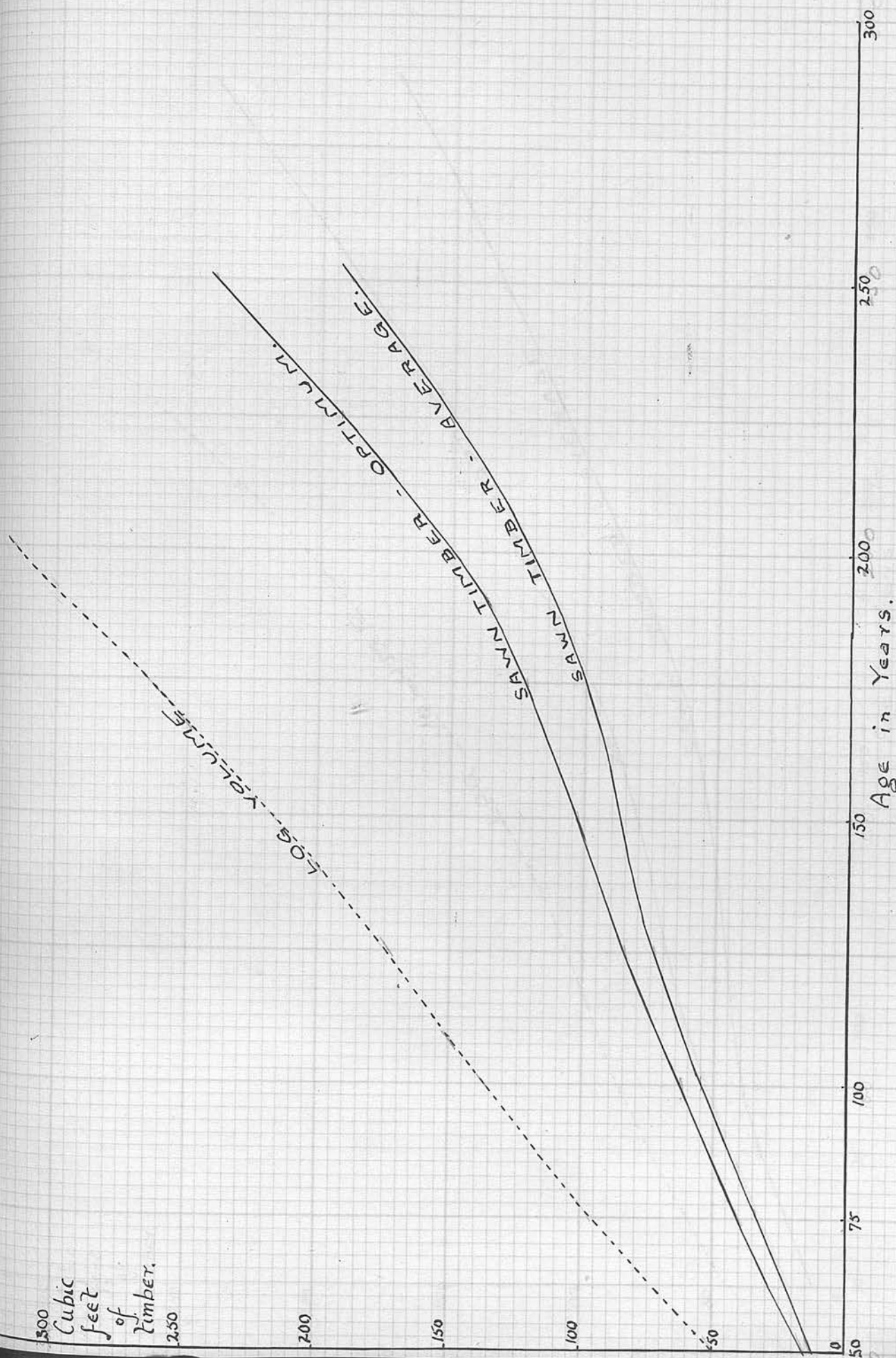
SAWN TIMBER OUTPUT.

AVERAGE FOR THE THREE ECOLOGICAL ZONES.

AGE.	MOIST ZONE	DRY ZONE	ARID ZONE
100	55	m43	20
159	87	58	35
200	122	95	45
250	188	145	60

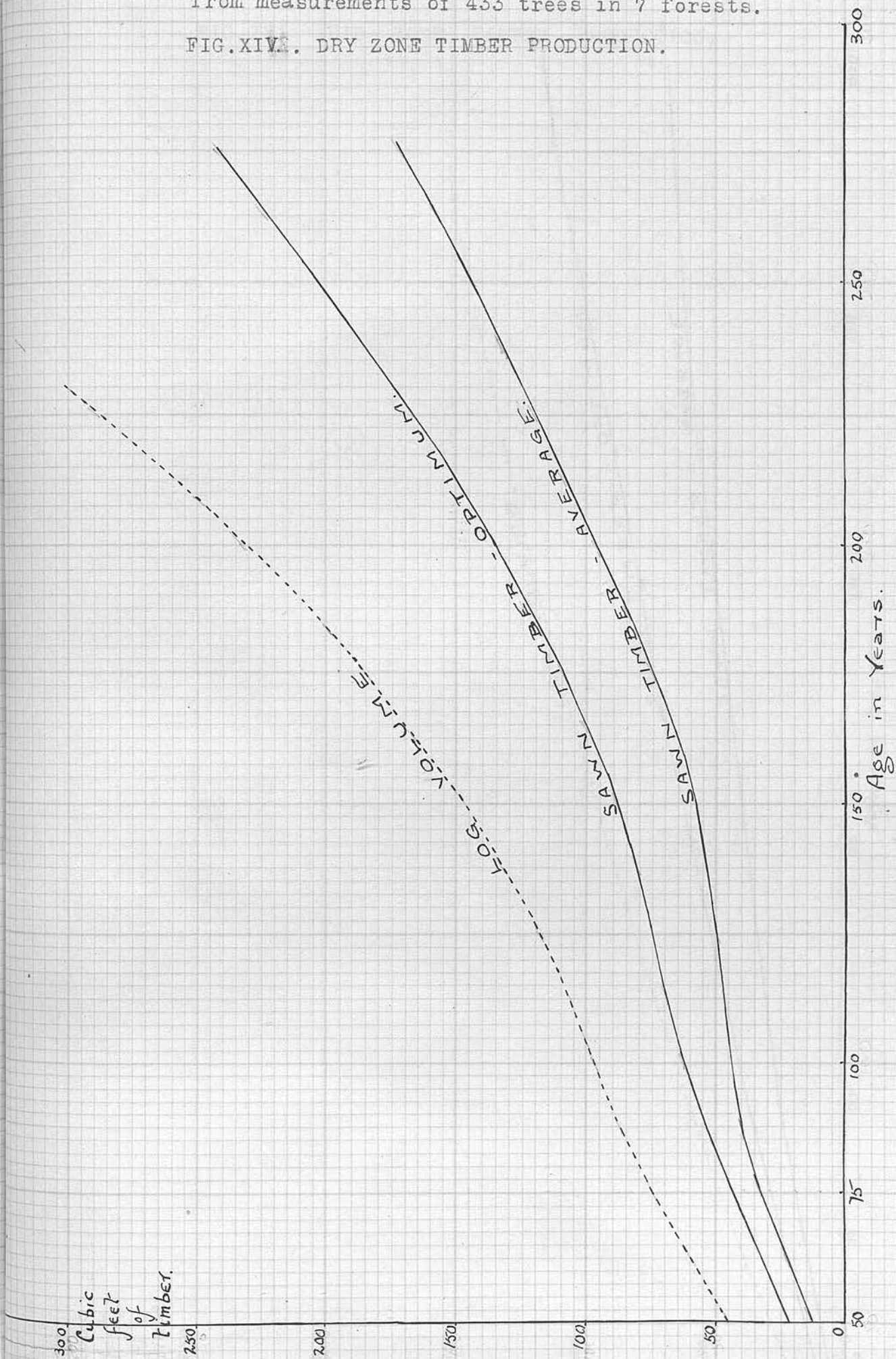
Curves of Average and Optimum Output of Sawn Timber
from measurements of 109 trees in 4 forests.

FIG. XIII. MOIST ZONE TIMBER PRODUCTION.



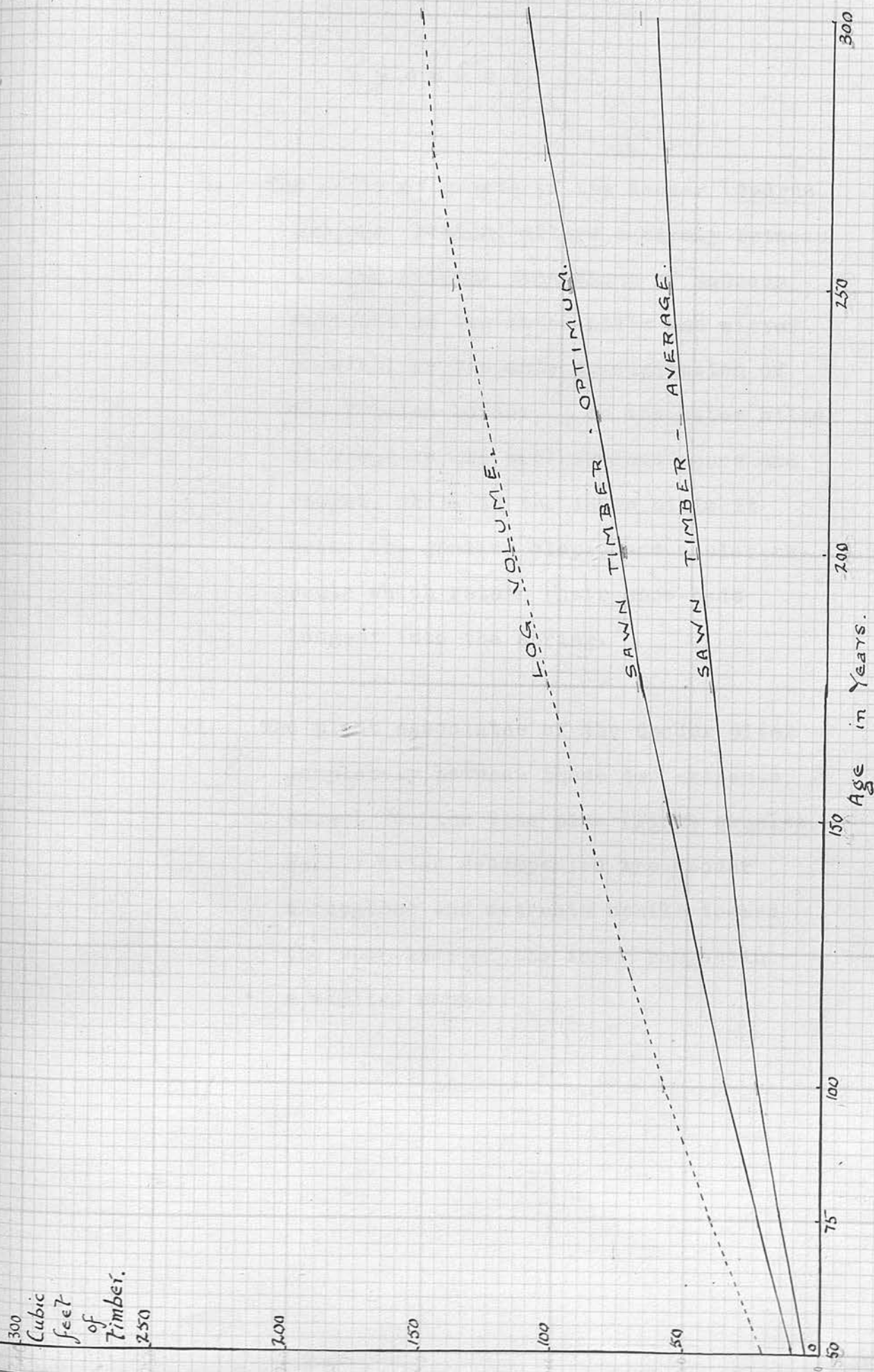
Curves of Average and Optimum Output of Sawn Timber
from measurements of 433 trees in 7 forests.

FIG. XIV. DRY ZONE TIMBER PRODUCTION.



Curves of Average and Optimum Output of Sawn Timber
from measurements of 86 trees in 4 forests.

FIG. XV. ARID ZONE TIMBER PRODUCTION.



S U M M A R Y.

- I. The habit of growth of the deodar (Cedrus Deodara, Loudon) alters entirely between the two extreme conditions of monsoon rainfall in the outer hills and winter snowfall as the only precipitation of the Tibetan border. In the outer hills it keeps to the best drained spurs and ridges, while in the inner hills it seeks the gentler slopes and cooler aspects which retain their snow-beds longest into the spring.
- II. The plant associates of the deodar alter completely between these two extremes, except for the blue pine (Pinus excelsa, Wall.) which accompanies the deodar throughout and retreats uphill toward the snow-beds of the inner ranges in a similar manner.
- III/

- III. The deodar's capacity as a timber producer alters markedly with climatic changes, and these alterations have now been correlated with the changes in its plant associates.
- IV. For practical use in the field, the deodar itself is the best indication of the quality class of any existing crop, and it is proposed to employ vegetation lists only in the determination of the site quality class, where the existing crop is an abnormal one. The plants which indicate optimum conditions for deodar may be summarised as follows:-

Moist Zone (deodar in mixed crops
with spruce and blue pine)
Adiantum Capillus-Veneris, Linn and
venustum, Don.
Ainsliaea aptera, DC.
Arundinaria falcata, Nees.
Asparagus filicinus, Buch-Ham.
Fragaria vesca, Linn.
Primula denticulata, Sm.
Smilax parvifolia, Wall. and vaginata,
Decne.
Spiraea bella, Sims. and vestita, Wall.
Urtica dioica, Linn.
Viola Patrinii, Ging. and serpens, Wall.
Wulfenia Amherstiana, Benth

Dry/

Dry and Arid Zones (deodar in pure crops).

Artemisia vestita, Wall.
Asparagus gracilis, Royle.
Astragalus chlorostachys, Lindl.
Atropa Belladonna, Linn.
Bupleurum Candollii, Wall. and
lanceolatum, Wall.
Desmodium tiliaefolium, G.Don.
Fragaria vesca, Linn.
Indigofera Gerardiana, Wall.
Lilium polyphyllum, D.Don.
Philadelphus tomentosus, Wall.
Polygonatum multiflorum, All. and
verticillatum, All.
Polygonum affine, D.Don and *molle*,
D.Don.
Thalictrum foliolosum, DC., *javanicum*,
Blume., and *minus*, Linn.
Viola Patrinii, Ging. and *serpens*,
Wall.

- V. In employing the vegetation lists presented in this paper, the ground flora in any given deodar crop or planting area should be studied and compared with the listed normal for the area, according to its position in the moist, dry, or arid zone, and the peculiarities of the common plants should be referred to in the analysis (CHAPTER VIII).
- VI. As the ground flora of deodar crops with a complete canopy consists largely of herbs, it follows that the whole of the ground/

ground cover, including herbs, ferns, and grasses as well as shrubs, should be studied for guidance in silvicultural work.

VII. Experience has shown that the drier types of deodar forest require a slower and more gradual method of regeneration than the orthodox Shelterwood System, and that marking for felling must be governed largely by the necessity for providing side shade against the hottest sun until young crops are established. A study of the component plants of the ground cover will give useful indications as to the amount to which any given crop should be opened up.

3 : 5 : 30.

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TEHRI
GARHWAL

- State Boundary
Range do.
Forest do.
Compartment do.
H.T. Road
Streams
Public Works Department Bungalow
Forest Bungalow
Range Bungalows
Range Numbers
Compartment Letters
a, b, c

ARID ZONE

DRY ZONE

ONE

April 1930





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- State Boundary
- Range do.
- Forest do.